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Chapter 5

Cumulative Effects

Cumulative effects are defined by the Council on Environmental Quality (CEQ) (40 CFR 1508.7) as the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time. Cumulative effects can result from actions that occur many years before or after the proposed project is implemented.

Cumulative effects analyses have been further elaborated and their importance emphasized by a number of federal court decisions and research studies. These directives and guidance documents were summarized by the Texas Department of Transportation (TxDOT) in a September 2010 guidance document, which requires that for Environmental Impact Statements (EIS), Environmental Assessments (EA), and some Categorical Exclusions (CE), indirect and cumulative effects assessments shall: (1) be addressed individually in separate sections of the environmental document; and (2) follow prescribed step-wise methodologies.

Federal Highway Administration (FHWA) adopts the CEQ definition of cumulative effects in 40 CFR 1508.7, but notes that, "these impacts are less defined than secondary effects. The cumulative effects of an action may be undetectable when viewed in the individual context of direct and even secondary impacts, but nonetheless can add to other disturbances and eventually lead to a measurable environmental change" (FHWA 1992).

Indirect effects and cumulative effects are analyzed separately because of key inherent differences in the nature of the effects and the ways in which they are identified and measured. For example:

Indirect effects are (or will be):

- Caused by the proposed action
- Analytically focused on the impact-causing activities associated with the proposed action and its alternatives and the environmental impacts associated with those activities

Cumulative effects are:

- Past, present, or reasonably foreseeable future impacts whose environmental effects should be assessed whether or not they are caused by the lead or sponsoring agency or some other agency or person

- Analytically focused on the resources. The cumulative effects analysis requires a sufficient understanding of resource conditions to know if an action may constitute "individually minor but collectively significant actions." That is, is there a "tipping point" situation that should alert the decision maker and others with resource protection responsibilities, public or private, that a mitigation response should be considered?

In accordance with TxDOT's (2010e) guidelines, the analysis of cumulative effects includes the following steps:

1. Identify the resources to consider in the analysis;
2. Define the study area for each affected resource;
3. Describe the current health and historical context for each resource;
4. Identify direct and/or indirect impacts that may contribute to a cumulative impact;
5. Identify other reasonably foreseeable actions that may affect resources;
6. Assess potential cumulative impacts to each resource;
7. Report the results; and
8. Assess and discuss mitigation issues for all adverse impacts.

These steps and related findings are presented in the following subsections.

Note on the Relationship between Resource Study Areas (RSAs) and the Project Area of Influence (AOI)

The methodology in this cumulative effects assessment also follows the methodological guidance set out in case law (Fritiofson v. Alexander, 772 F2nd 1225, 5th Circuit, 1985) as well as guidance provided by the CEQ (1997) in *Considering Cumulative Effects under the National Environmental Policy Act*. Fritiofson laid down some explicit elements that are important to the cumulative effects analysis of the proposed US 281 improvements.

"A meaningful cumulative effects study must identify:

1. The area in which effects of the proposed project will be felt
2. The impacts that are expected in that area from the proposed project
3. Other actions—past, proposed, and reasonably foreseeable—that have had or are expected to have impacts in the same area
4. The impacts or expected impacts from these other actions
5. The overall impact that can be expected if the individual impacts are allowed to accumulate."

The cumulative effects guidance documents (TxDOT 2010e, CEQ 1997) encourage delineation of liberally defined resource study areas (RSA) specific to the scientific characteristics of the resource. However, Fritiofson makes it clear that for the purpose of accounting for the cumulative impacts of a project, which by definition adds the project's direct and indirect impacts to all other reasonably foreseeable future actions, the AOI is an appropriate boundary for analysis and quantification of effects. For this study, cumulative effects to each resource are analyzed in the context of their specific RSAs however, the quantification of the cumulative impacts of the proposed Build Alternatives is limited to the area in which direct and indirect effects of the proposed project will be felt — the AOI.

In addition to the above methodology, other qualitative and quantitative tools were used to forecast cumulative impacts. Qualitative input was gathered from a panel of land use planning and development experts through their participation in two collaborative judgment workshops held specifically for the US 281 EIS project. The Land Use Panel members were asked to designate areas of anticipated development with and without the project on maps (see **Section 4.6.2**). This information was synthesized into thematic maps, and quantification of the associated acreage was then generated using GIS. Estimates of future population growth and residential development in the AOI are based on regional water planning projections (TWDB 2009b), data from the U.S. Census Bureau (2010b), and population and housing projections developed for this EIS by SA Research Corporation (2010).

Quantifications used to describe cumulative effects are approximate and should be considered on a resource by resource basis, keeping in mind the limitations associated with the probabilistic nature of some predictive methods. These limitations are discussed in **Section 4.6.3**.

Specific assumptions were made in this analysis:

- Assumption 1: Water demand projected for the region by the Texas Water Development Board (TWDB) through 2030 will be fully satisfied by the development of future water supply projects identified by the South Central Texas Regional Water Plan (SCTRWP) and other water agencies.
- Assumption 2: Water supply for the region through the year 2030 assumes that at least 320,000 acre-feet of groundwater will be available annually from the southern (San Antonio) segment of the Edwards Aquifer even during conditions equivalent to the drought of record. This does not include any droughts of longer duration or frequency predicted by climate change models. Possible variations to this assumption associated with climate change are discussed in **Section 5.3.4**

5.1 STEP 1: IDENTIFY THE RESOURCES TO CONSIDER IN THE ANALYSIS

This section represents Step 1 in conducting the cumulative effects analysis, which focuses on resources that can be meaningfully evaluated, with a strong emphasis on resources that are likely to be substantially affected by the proposed project. Generally, if a project does not cause direct or indirect impacts on a resource, it will not contribute to a cumulative impact on that resource (TxDOT 2010e). However, where it appears that other past, present or reasonably foreseeable future actions within the region may put the sustainability of one or more resources at risk, even minor consequences of the proposed project that could contribute to that decline are worthy of careful evaluation. The following resource categories have been identified for possible evaluation of cumulative effects:

1. Land resources and uses
2. Socioeconomic and community resources
3. Air quality
4. Water resources – surface water
5. Water resources – ground water
6. Ecological resources – vegetation and wildlife habitat
7. Ecological resources – threatened and endangered species
8. Archeological resources

9. Historic resources

Table 5-1 identifies the direct and indirect impacts found in **Chapter 3 Affected Environment and Environmental Consequences** and **Chapter 4 Indirect Effects** that have potentially adverse effects on one or more resources and describes the resources that may be unstable or in poor health. The table also provides a brief rationale for either inclusion or exclusion from the more detailed evaluation of possible cumulative effects. Certain issues, such as noise or displacements, are not addressed directly; however, insofar as these issues affect key resources, (the way noise affects a neighborhood's quality of life, or how business displacements may affect vulnerable elements of the population), they are considered in the cumulative perspective, with a focus on their place in the larger geographic and temporal context of the community. Archeological and historic resources would not be expected to undergo substantial direct or indirect impacts as a result of the proposed project. Nonetheless, these resources are included in the cumulative effects analysis due to the potential threat to the stability and health of these resources that reasonably foreseeable future actions within their respective RSAs represent. RSAs for each of the resources addressed in **Table 5-1** are discussed in **Section 5.2.1** through **5.2.4** .

Table 5-1: Determination of Resources and Issues Included in the Cumulative Effects Analysis

Resource	Would Proposed US 281 Corridor Project Potentially Result in Adverse Direct or Indirect Impacts? (1)	Is Resource/Issue At Risk or in Poor or Declining Health? (2)	Is Resource or Issue Included in Cumulative Effects Analysis?	Reason for Including or Excluding key Issues for Cumulative Effects Analysis
Land Resources and Uses	Yes	Yes Some land use categories e. g. agricultural land, particularly small farms and ranches, may be at risk from future development	Yes	Reasonably foreseeable future development, including induced growth, is likely to result in conversion of agricultural, open space, and undeveloped land uses.
Socioeconomic and Community Resources	Yes	Yes Most neighborhoods and communities in the Socioeconomic and Community RSA are currently stable but could experience growth pressure from reasonably foreseeable development.	Yes	Socioeconomic and land use effects will vary with the pace and type of development, and should be viewed in the larger context of corridor-wide mobility and safety improvements.
Air Quality	No	No Effective July 12, 2012, The San Antonio Air Quality Planning Area, which includes Bexar and Comal Counties, is in attainment of air quality standards under the Clean Air Act.	No	Resources not directly or indirectly affected are not included in the cumulative effects analysis.

Table 5-1: Determination of Resources and Issues Included in the Cumulative Effects Analysis

Resource	Would Proposed US 281 Corridor Project Potentially Result in Adverse Direct or Indirect Impacts? (1)	Is Resource/Issue At Risk or in Poor or Declining Health? (2)	Is Resource or Issue Included in Cumulative Effects Analysis?	Reason for Including or Excluding key Issues for Cumulative Effects Analysis
Water Resources	Yes	Yes The status and viability of ground and surface water resources is a function both of water supply and water quality. The current health of water resources in the Water RSA is considered stable but additional water supplies are needed to support projected future regional water demand. The quality of surface and ground water is at risk due to a likely increase in impervious cover and contaminant runoff from future development, with additional risk for groundwater contamination from surface pollutants and subsurface aquifer contamination.	Yes	Future water supply issues are addressed with the assumption that the identified regional water development strategies will be implemented as planned. The cumulative effects on water quality will focus on the potential for induced and other reasonably foreseeable urban development in the Water RSA that may adversely affect surface water quality.
Ecological Resources - Vegetation and Wildlife	Yes	Yes Although the health of ecological resources, including wildlife habitat and vegetation, is presently stable it is likely that there will be a future decline in habitat quality and quantity as a result of induced growth as development occurs within the Ecological RSA.	Yes	Wildlife habitat and utilization by wildlife resources is affected by current and future land use change due to induced and other reasonably foreseeable cumulative impacts. The most valuable habitats include upland wooded, riparian, aquatic habitats, and those that support protected species.
Ecological Resources – Threatened and Endangered Species	Yes	Yes Federally- and state-listed species are by definition at risk.	Yes	Development effects on potential existing habitat are likely.

Table 5-1: Determination of Resources and Issues Included in the Cumulative Effects Analysis

Resource	Would Proposed US 281 Corridor Project Potentially Result in Adverse Direct or Indirect Impacts? (1)	Is Resource/Issue At Risk or in Poor or Declining Health? (2)	Is Resource or Issue Included in Cumulative Effects Analysis?	Reason for Including or Excluding key Issues for Cumulative Effects Analysis
Archeological Resources	No	No Coordination between TxDOT and the THC[1] determined that the US 281 Corridor project would not result in direct or indirect impacts to archeological resources within the Area of Potential Effects (APE), which includes the existing US 281 right-of-way, the right-of-way for the proposed Build Alternatives, and areas related to project construction. Areas beyond the APE but within the Land RSA may be subject to future development which could adversely affect currently probable but currently unidentified archeological resources. No archeological surveys beyond the APE were conducted for the proposed project.	No	According to TxDOT guidance, resources that are not directly or indirectly affected are not included in the Cumulative Effects assessment.
Historic Resources	No	No Coordination between TxDOT and the THC[2] determined that the US 281 Corridor project would not result in direct or indirect impacts to historical resources within the Area of Potential Effects (APE), which includes all parcels contained or partially contained within 150 feet of the right-of-way of the proposed Build Alternatives. Areas beyond the APE but within the Land RSA may be subject to future development which could adversely affect currently undesignated historical resources, which contribute to the character and cohesion of communities in the Land RSA. No historical resource surveys beyond the APE were conducted for the proposed project.	No	According to TxDOT guidance, resources that are not directly or indirectly affected are not typically included in the Cumulative Effects assessment.

Source: US 281 EIS Team 2011
Notes: (1) Based on evaluations presented in Chapters 3.0 and 4.0 (2) Discussed in greater detail in Section 5.3

[1] Coordination pursuant to Section 106 of the National Historic Preservation Act (NHPA) and the 2005 First Amended Programmatic Agreement among FHWA, TxDOT, the State Historic Preservation Officer (SHPO), and the Advisory Council on Historic Preservation (PA-TU).

5.2 STEP 2: DEFINE THE STUDY AREA FOR EACH RESOURCE

This section represents Step 2 in conducting the cumulative effects analysis. The RSA for each resource was chosen based on characteristics of the resource and the context and scale of the proposed US 281 Corridor Project (**Table 5-2**). The RSAs were reviewed from both temporal and geographic perspectives. The timeframe for consideration of cumulative effects varies and is described in each resource section.

Table 5-2: Resource Study Area for Each Resource Considered in the Analysis

Land Resources	Coterminous with AOI (**Figure 5-1**)
Socioeconomic and Community Resources	Similar to Land RSA with information collected for 22-selected quad data area (**Figure 5-2**)
Water Resources – Surface Water	Watersheds and associated tributaries within portions of Bexar, Blanco, Comal, Hays, and Kendall Counties (**Figure 5-3**)
Water Resources - Groundwater	Contributing, recharge, transition, and confined zones of the Edwards Aquifer (**Figure 5-4**)
Ecological Resources – Vegetation and Wildlife	Vegetation types within watershed boundary (**Figure 5-5**)
Ecological Resources – Threatened and Endangered Species	Varies according to each species range, generally by Recovery Plan zones for major species (**Figure 5-6** through **Figure 5-8**)

Source: US 281 EIS Team 2011

5.2.1 Land Resources Study Area

Geographic Description

The Land RSA (**Figure 5-1**) evaluated for cumulative effects is the same as the Area of Influence (AOI) for indirect effects assessment. It was developed using a two-tiered approach, described below.

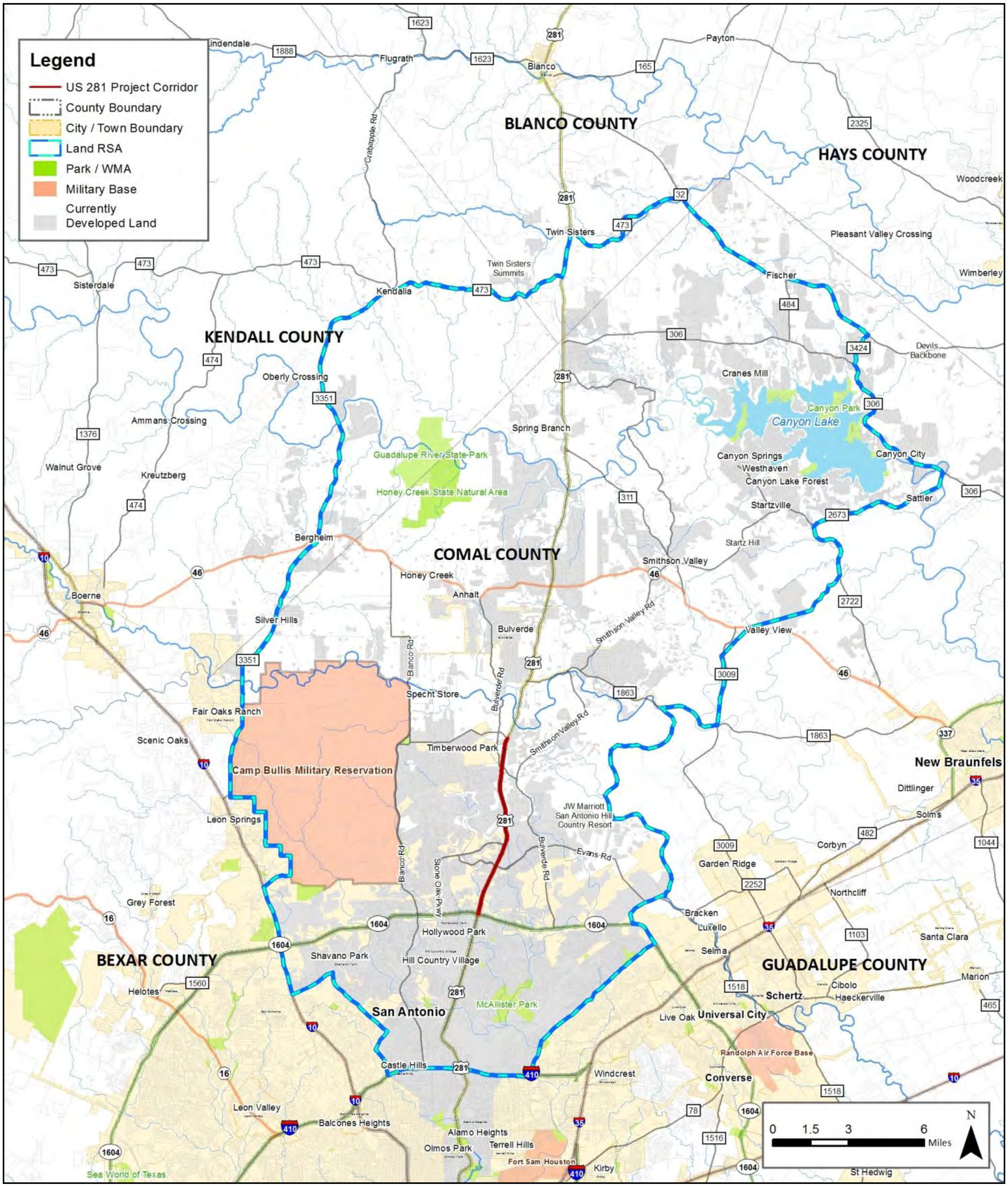
Tier 1: Land Data Collection Area

For preliminary data collection efforts, an area comprised of 22 USGS 7.5 minute quadrangles was delineated, generally along the US 281 Corridor, from Loop 410 northward into Comal, Kendall, and Blanco Counties. The USGS quads provide a familiar and convenient source of data that are the basis for several other data sets used in the indirect and cumulative effects analyses (for example, Texas Parks and Wildlife Department's (TPWD) Natural Diversity Database (TxNDD), and US Fish and Wildlife Service's (USFWS) National Wetlands Inventory (NWI). Available natural, cultural, and community resource information for this area was compiled and mapped. Some RSAs extend beyond this area, such as surface water, ground water, and some components of ecological resources. Some land features and land use information was gathered for the larger area, but collection and presentation of more detailed and quantified land and land use information is limited to the AOI.

Tier II: Resource Study Area

The Land RSA is the area within which reasonably foreseeable future development actions are to be identified and, where possible, quantified. Consistent with agency and judicial guidance, the Land RSA is the same as the AOI. Conforming the Land RSA to the boundaries of the AOI enabled more detailed quantitative information for comparison with development information from the indirect and cumulative effects analyses. The Land RSA boundary is depicted in **Figure 5-1**.

Figure 5-1: Land RSA



Source: US 281 Team, 2011

Temporal Boundaries

The period of review for land resources begins in the mid-1960s with the substantial rise in development near the newly completed Canyon Lake and extends to 2035, consistent with the planning horizon for the San Antonio-Bexar County Metropolitan Planning Organization's (SA-BC MPO) *Mobility 2035.*

5.2.2 Socioeconomic and Community Resources Study Area

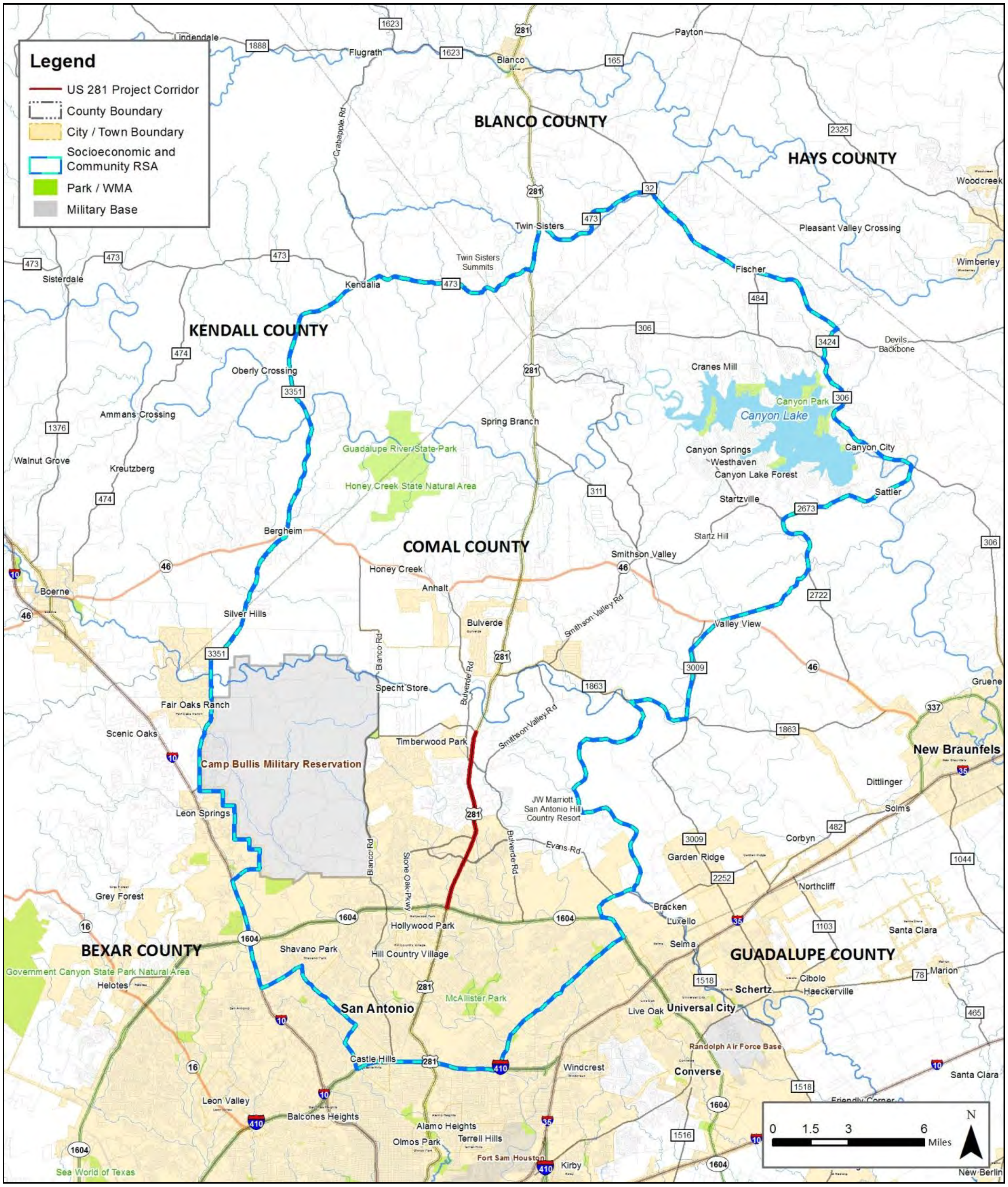
Geographic Description

The Socioeconomic and Community RSA is equivalent to the Land RSA. The evaluation is intended to be flexible, however, to address community resources that may lie beyond the Land RSA boundary; consideration was given to their potential scarcity, value, or fragility. The Socioeconomic and Community RSA, with selected towns and community features, is shown on **Figure 5-2**.

Temporal Boundaries

The socioeconomic and community resources review focuses on the period of substantial urban and suburban development within the RSA that began with the construction of Canyon Lake in the mid 1960s and extends to 2035.

1 **Figure 5-2: Socioeconomic and community RSA**



2

3 Source: US 281 Team, 2011

5.2.3 Water Resources Study Areas

Surface Water

Geographic Boundaries
The Surface Water RSA (**Figure 5-3**) encompasses portions of Bexar, Blanco, Comal, Guadalupe, Hays, and Kendall counties. This RSA includes the watersheds of the rivers and their respective tributaries that have a potential to be indirectly or cumulatively impacted by the proposed US 281 Corridor Project.

The majority of the rivers and creeks in the project area flow from west-northwest to east-southeast, terminating at the Gulf of Mexico. Wetlands within the Surface Water RSA are limited. There are no natural lakes within the Surface Water RSA and there is one large man-made public reservoir, Canyon Lake.

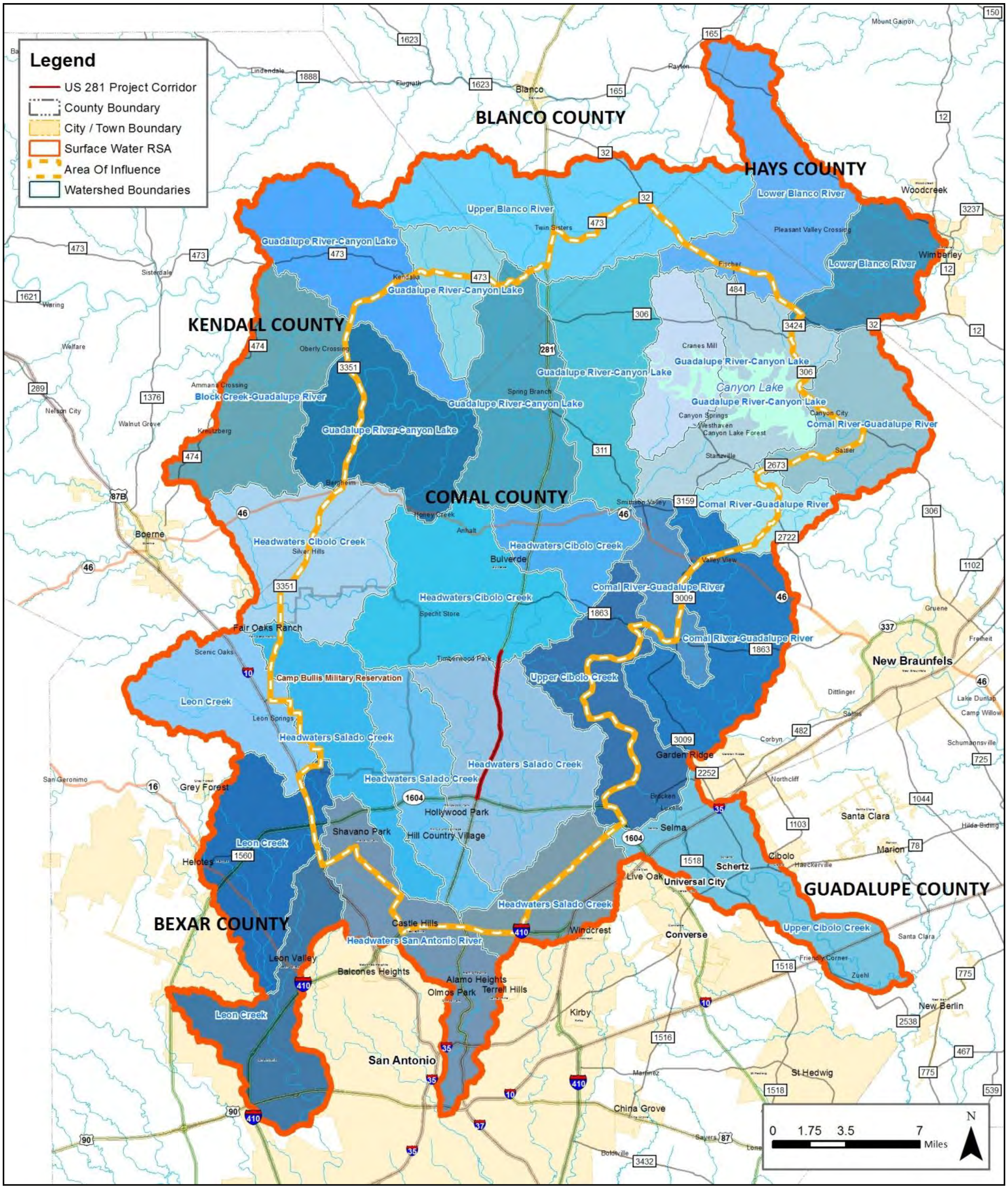
Temporal Boundaries
The surface water cumulative effects evaluation focuses on the hydrological period of record (1934 to 2008) projected to 2030, an interim planning horizon used by the TWDB in the 2007 State Water Plan, *Water for Texas 2007*. The period of record of 1934 to 2008 was chosen as a representative period for water resources records relevant to the Surface Water and Ground Water Resource Study Areas, based on the range of periods of record maintained by the United States Geological Survey (USGS) in their National Water Information System (USGS 2011).

Groundwater

Geographic Boundaries
The Groundwater RSA **(Figure 5-4)** includes the contributing, recharge, transition, and confined zones of the Edwards Aquifer, the principal aquifer within the AOI, and extends northeast to include Comal and San Marcos Springs. Portions of the Trinity Aquifer are also located within the Groundwater RSA. The Edwards Aquifer is currently the most relevant and important in regards to San Antonio's public water supply and the Trinity Aquifer provides water to many of the surrounding communities.

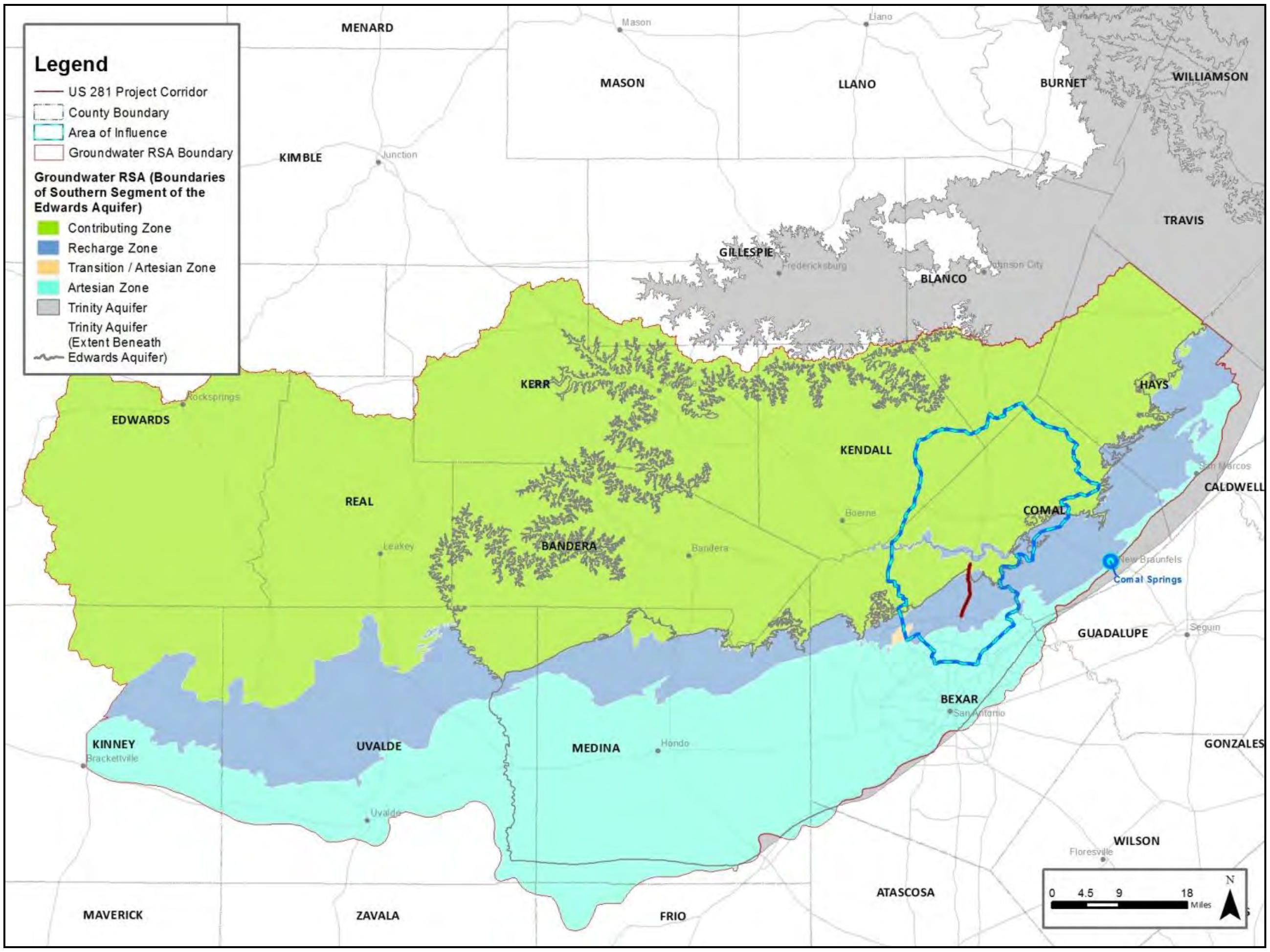
Temporal Boundaries
The cumulative effects evaluation for groundwater will focus on the representative hydrological period of record (1934 to 2008) projected to 2030, the State of Texas interim water planning horizon.

Figure 5-3: Surface water RSA



Source: US 281 Team, 2011

Figure 5-4: Groundwater RSA



Source: US 281 Team, 2011

5.2.4 Ecological Resources Study Areas

Ecological resources include aquatic and terrestrial wildlife species and associated habitats including threatened and endangered species. For the purposes of this cumulative effects evaluation, ecological resources have been divided into two primary groups: (1) vegetation and wildlife habitat; and (2) threatened and endangered species.

Vegetation and Wildlife

Geographic Description

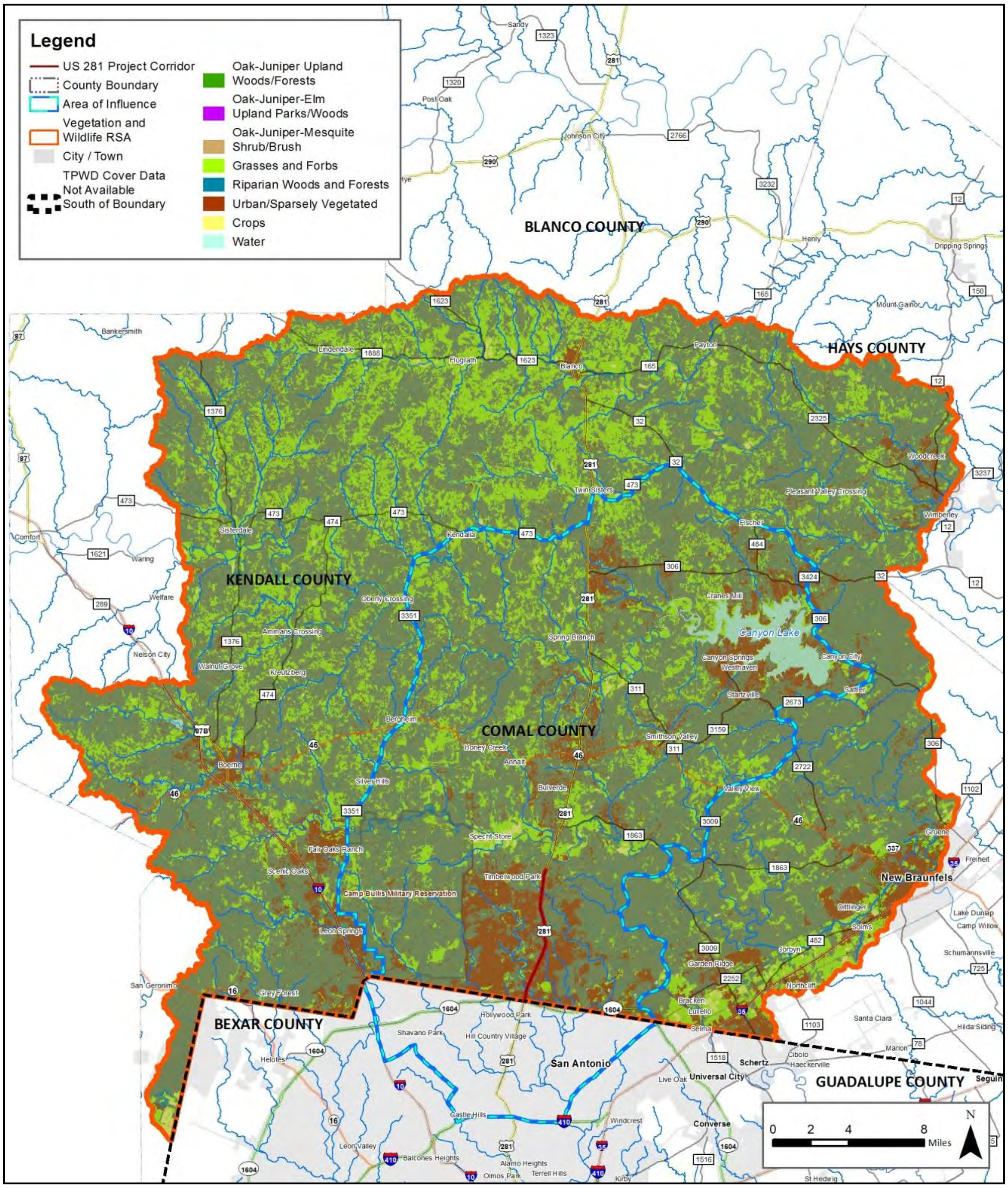
The Vegetation and wildlife RSA includes the vegetative types mapped under Phase 1 of the TPWD's *Texas Ecological Systems Classification Project* (2010h) and is represented by (**Figure 5-5**). The southern boundary of the Vegetation and wildlife RSA is represented by a line that shows the southern extent of the vegetation data classified and mapped by Phase 1 of the TPWD mapping project.

Vegetation mapped to the south of the Vegetation and wildlife RSA boundary (Phase 3 of the TPWD Project) was not available in a format suitable for this evaluation as of Fall 2010, but covers areas of the Vegetation and wildlife RSA that are highly developed.

Temporal Boundaries

The cumulative effects evaluation for vegetation and wildlife ecological resources covers the period of substantial urban and suburban development that began with the construction of Canyon Lake in the mid-1960s and extends to 2035.

Figure 5-5: Vegetation and wildlife RSA



Source: Texas Parks and Wildlife Department, 2010 (Ecological Systems Classification and Mapping Project), US 281 Team, 2011

Threatened and Endangered Species – Management Units

Within the Threatened and Endangered Species RSAs used for cumulative effects analysis there are several threatened and endangered species. These areas have unique habitat types such as terrestrial karst and sub-surface aquifer environments as well as oak-juniper woodlands and canyonlands that are all threatened by increasing development pressure. In response to this pressure, TPWD and U.S. Fish and Wildlife Service (USFWS) have listed many of these species as threatened or endangered in order to protect the species and their habitats. Listed species are recipients of additional study and, where applicable, recovery plans and habitat conservation plans have been developed, and critical habitat has been designated and is monitored and mapped by a variety of agencies. To provide context for the RSAs for these species, definitions of some of the management units used to list, map, and monitor conservation efforts for threatened and endangered species and their habitats are provided below. For each of the threatened and endangered species, the temporal RSA extends to the year 2035.

Recovery Plan Regions

USFWS recovery plans are based upon a geographic area coinciding with the entire range where the subject species is known to occur. For endangered migratory songbirds such as the golden-cheeked warbler (GCWA) and black-capped vireo (BCVI), for example, the recovery plan area tends to coincide with the U.S. breeding range for the species. Given the large size of these ranges, the area is further broken up into recovery regions defined in varying ways. These might be separated by differing geographic attributes, vegetation types, ecoregions, watersheds, or socio-political boundaries (e.g. county lines) which provide focal areas for conservation and recovery efforts. A somewhat different approach is taken for geographically restricted species such as karst invertebrates (see **Karst Fauna Regions** below).

Critical Habitat

Under the Federal Endangered Species Act, critical habitat is a specific geographic area(s) that contains habitat features considered essential for the conservation of a threatened or endangered species and that may require special management and protection. For an area to be designated as critical habitat, it must first be published in the form of a proposed rule in the *Federal Register* for public comment. Once comments are received and considered, the proposed area and its boundaries must be published again in the *Federal Register* before the critical habitat designation is final (USFWS 2009).

Critical Habitat Unit

Critical Habitat Units (CHUs) are individual geographic areas that make up the total critical habitat area designated by the USFWS for a species or group of species. Designated critical habitat areas may consist of numerous CHUs that are spatially disconnected (USFWS 2009).

Element Occurrence and Element Occurrence Record

An Element Occurrence is an area of land and/or water in which a species or natural community is, or was, present. An Element Occurrence should have practical conservation value for the species or natural community as evidenced by potential continued (or historical) presence and/or regular recurrence at a given location. Element occurrence records obtained from the Texas Parks and Wildlife Department's Natural Diversity Database (TXNDD) include information on the locations, status, characteristics, numbers, condition, and distribution of elements of biological diversity using the established Natural Heritage Methodology developed by Nature Serve and The Nature Conservancy (TNC).

Karst Fauna Regions (KFRs)
Karst Fauna Regions are distinct geographic areas established by the USFWS that have restricted karst species population exchange. Geologic and topographic restrictions may form partial or complete barriers that inhibit species travel and gene flow (Veni 2002). Karst Fauna Regions are tools for guiding recovery efforts for the listed karst invertebrate species.

Karst Zones
Based on the geologic restrictions on the distribution of cave fauna and the locations of known caves, (Veni 1994, 2002) five karst zones have been delineated that reflect the relative likelihood of finding any of the Bexar County listed cave-dwelling species (and other rare endemic karst species). Karst zones are a guide for determining if species surveys are required prior to development activities. These five zones are defined as:

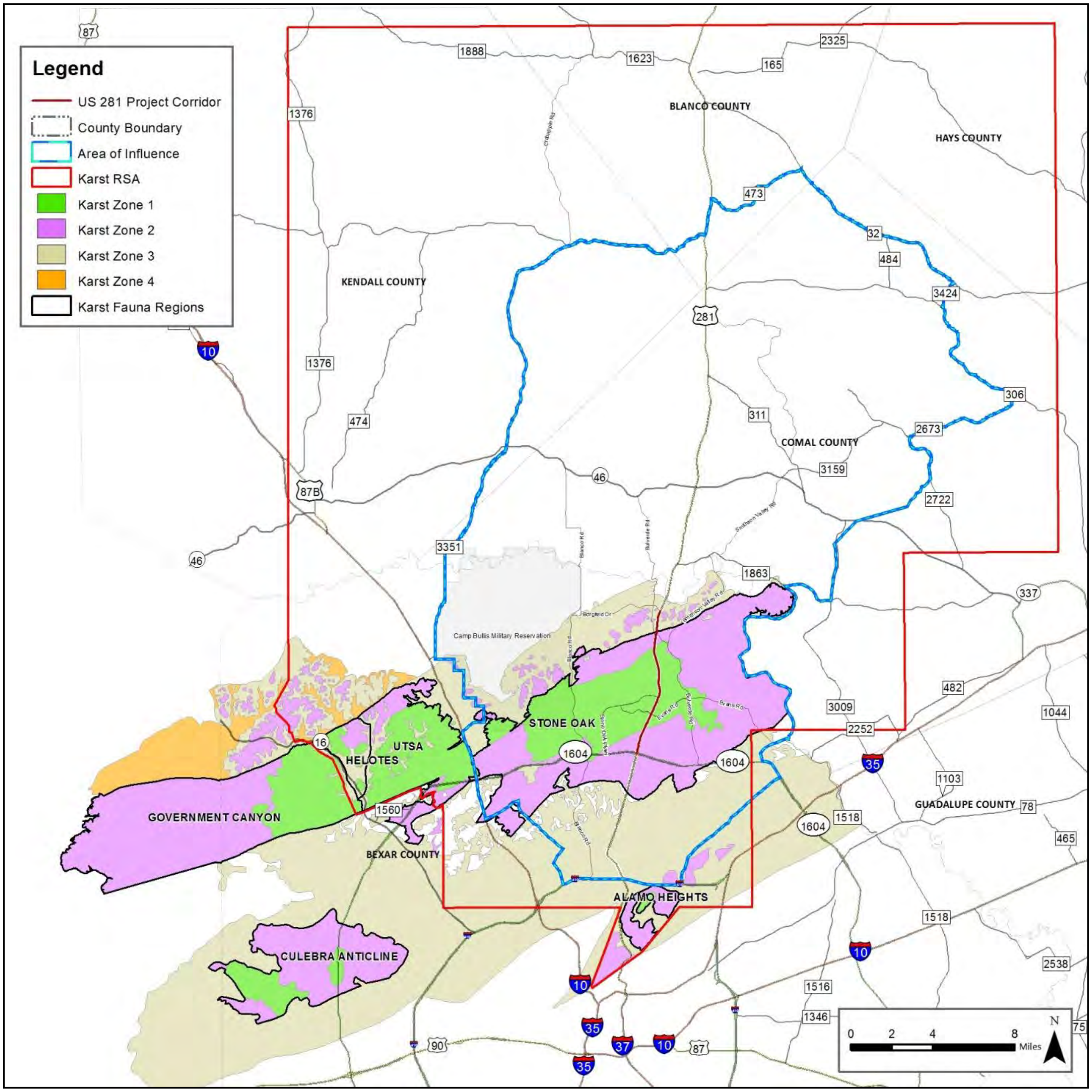
- Zone 1: Areas known to contain one or more of the listed karst invertebrates.
- Zone 2: Areas having a high probability of suitable habitat for the listed karst invertebrates.
- Zone 3: Areas that probably do not contain listed karst invertebrates.
- Zone 4: Areas that require further research, but are generally equivalent to Zone 3, although they may include sections that could be classified as Zone 2 or Zone 5.
- Zone 5: Areas that do not contain listed karst invertebrates.

Threatened and Endangered Species - Geographic Boundaries of Resource Study Areas

Surface Water Aquatic Species RSA (including Freshwater Mussels and Cagle's Map Turtle)
There are four species of freshwater mussels to be considered; all are currently listed as Threatened by TPWD and under consideration for federal listing by USFWS. Collectively, these species tend to inhabit flowing perennial streams and medium to large rivers; therefore, the Surface Water Aquatic Species RSA is analogous to the Surface Water RSA. The state-listed Threatened Cagle's map turtle is a Guadalupe River species and would be encompassed within the Surface Water RSA as well.

Terrestrial Karst Species RSA
The Karst invertebrate RSA (**Figure 5-6**) is similar to the Land RSA in Blanco, Comal, and Kendall counties, but in Bexar County the RSA covers the entirety of all KFRs that are intersected by the Land RSA. In Bexar County, the Land RSA intersects the Stone Oak, The University of Texas at San Antonio (UTSA), Helotes and Alamo Heights KFRs. KFRs have not been established by USFWS for the other counties included in the Land RSA. However, Comal County has identified karst habitat zones through the development of its Regional Habitat Conservation Plan (SWCA 2010).

Figure 5-6: Karst invertebrate RSA



Source: George Veni and Associates 2002, US 281 Team, 2011

Aquifer and Spring-Associated Species RSA (including aquifer dwelling invertebrates, salamanders and fish)

The RSA for aquifer and spring-associated species is largely the same as the Groundwater RSA (**Figure 5-4**), with the exception that the Aquifer and Spring-Associated Species RSA extends north to San Marcos Springs.

Terrestrial Reptile Species – Texas Horned Lizard RSA

The Texas horned lizard RSA corresponds to the Edwards Plateau ecoregion (www.tpwd.state.tx.us/huntwild/wildscapes/guidance/plants/ecoregions/), as analyzed in the TPWD *Texas Horned Lizard Watch 10 Year Summary Report* (Linam 2008).

Golden-cheeked Warbler RSA

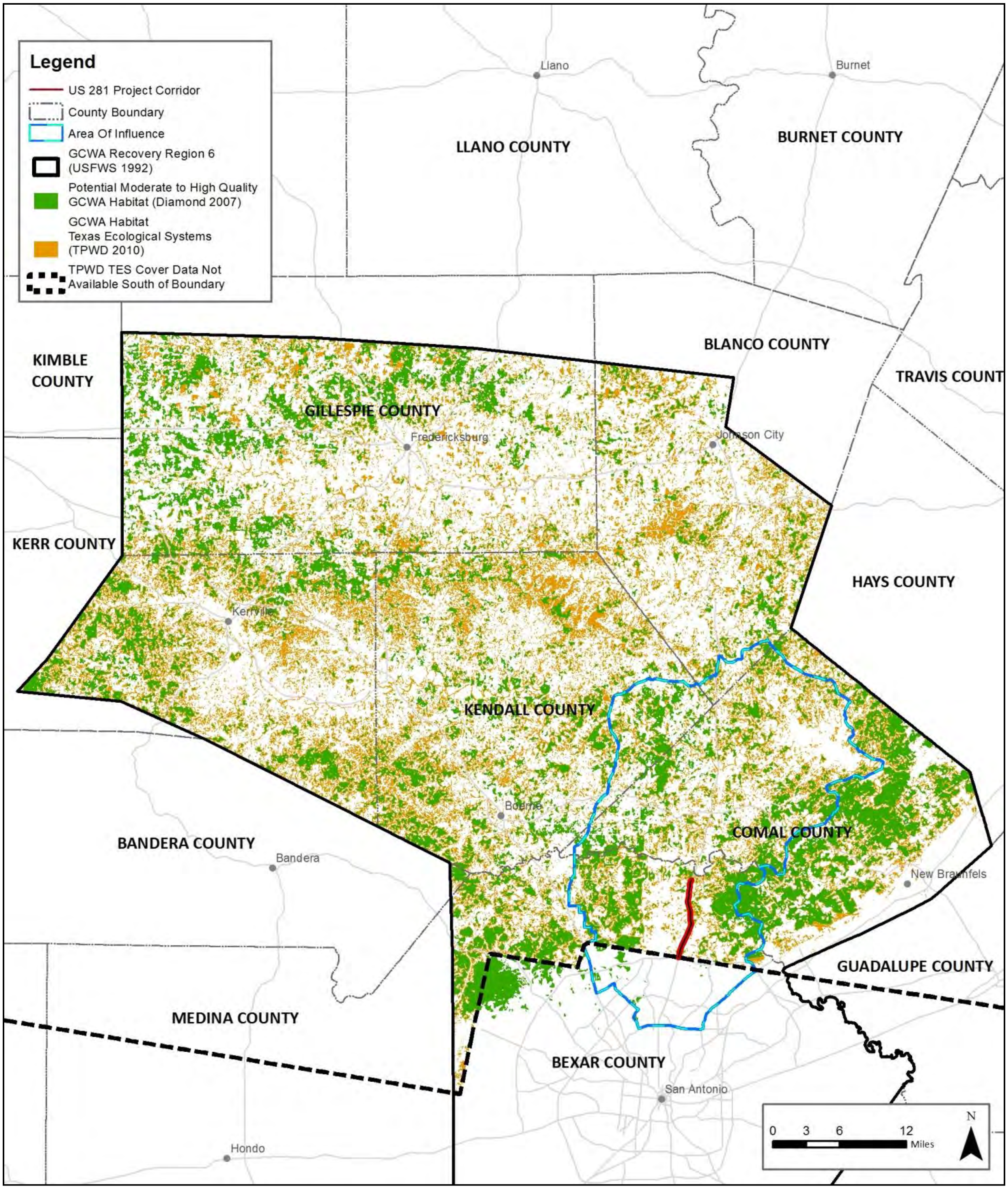
The RSA for the golden-cheeked warbler is Region 6 of the *USFWS Recovery Plan* (USFWS 1992) which is part of the entire breeding range found in Central Texas. The GCWA Recovery Plan is described in **Section 4.2**. Currently, the USFWS distribution map for the GCWA shows the species occurring in 37 counties in Texas on the Lampasas Cut Plain, the Edwards Plateau, and the Llano Uplift regions of Texas (USFWS 1992). This analysis will focus on the counties within Region 6 of the Recovery Plan, including all or portions of: Bexar (portion), Bandera (portion), Blanco (portion), Comal (all), Gillespie (portion), Kendall (all), and Kerr (portion) (**Figure 5-7**).

Black-capped Vireo RSA

The RSA for the black-capped vireo includes USFWS Recovery Region 3 – Southeast Edwards Plateau of the *USFWS Recovery Plan* (USFWS 1991), which is part of the entire breeding range which extends from Oklahoma, through central and west Texas, south through the Mexican states of Coahuila, Nuevo Leon, and southwestern Tamaulipas (Wilkins et al. 2006). According to the *USFWS Recovery Plan* (USFWS 1991), there were 34 counties in Texas known to be occupied by breeding BCVI in 1990 and surveys up to the year 2000 confirmed breeding in 38 Texas counties (USFWS 2007). Cumulatively, breeding populations have been documented in five Oklahoma counties, 49 Texas counties and three Mexican states since listing in 1987(USFWS 2007). This analysis focuses on all or portions of the counties that fall within USFWS Recovery Region 3 including: Bandera (all), Bexar (portion), Blanco (all), Burnet (portion), Comal (portion), Concho (portion), Crockett (portion), Edwards (portion), Gillespie (all), Hays (portion), Kendall (all), Kerr (all), Kimble (all), Kinney (portion), Llano (portion), Mason (all), McCulloch (portion), Medina (portion), Menard (all), Real (all), San Saba (portion), Schleicher (portion), Sutton (portion), Travis (portion), and Uvalde (portion) (**Figure 5-8**).

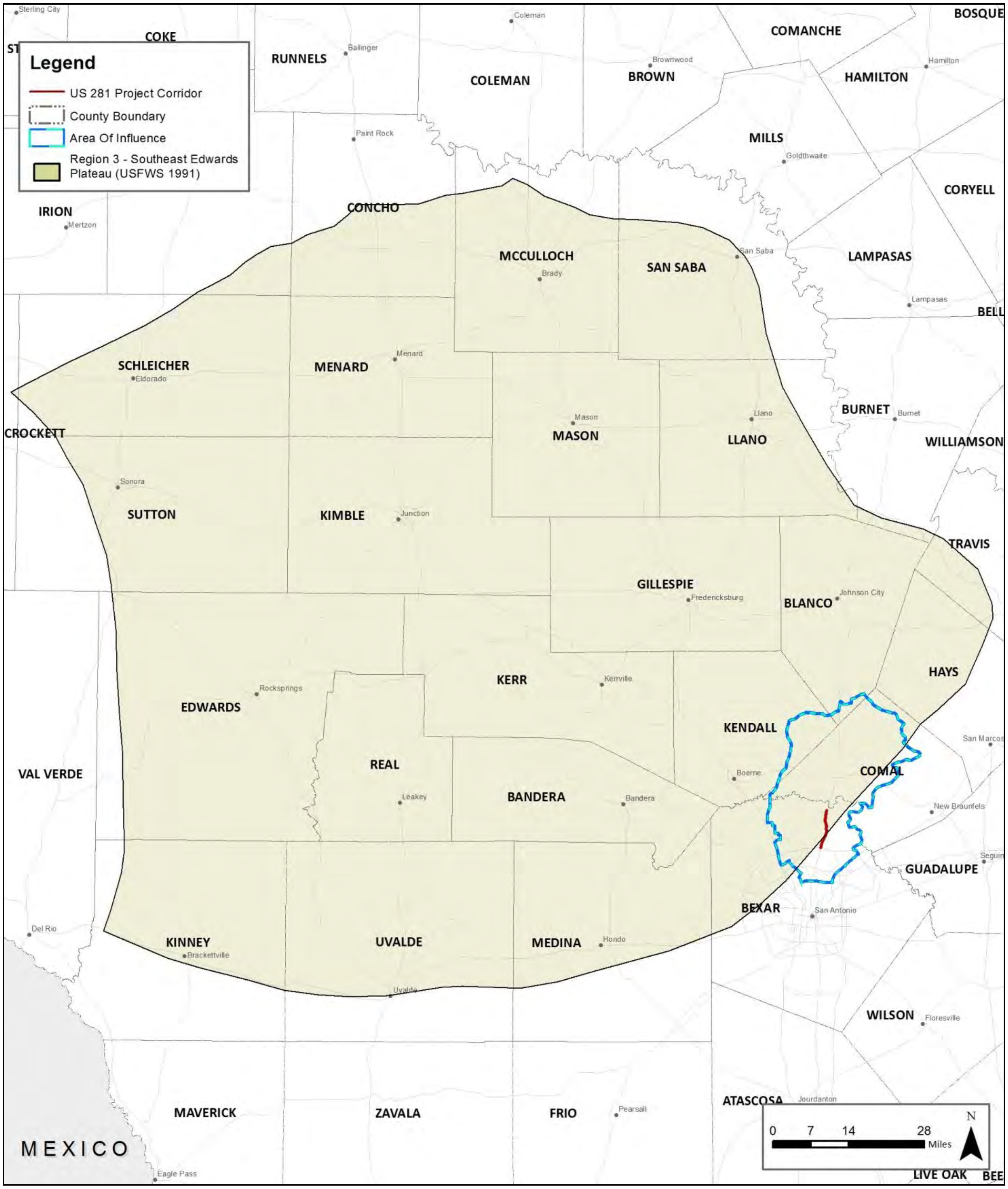
RSAs for all federally and state-listed threatened and endangered species and species of concern are indicated in **Table 5-3**. Species that are considered extirpated such as the San Marcos gambusia, black bear, gray wolf and red wolf have been omitted from the RSA descriptions and species overview sections. The jaguarundi, typically associated with extreme South Texas, and not documented recently there, has also been removed from the RSA and species overview sections.

Figure 5-7: Golden-cheeked warbler RSA



Source: US 281 Team, 2011

Figure 5-8: Black-capped vireo RSA



Source: US 281 Team, 2011

Table 5-3: County of Occurrence and Resource Study Areas for Federal and State-listed Species

Species	Federal Status	State Status	Habitat	Counties/RSAs
Plants				
Texas wild-rice *Zizania texana*	E/CH	E	Perennial, emergent, aquatic grass known only from the upper 2.5 km of the San Marcos River in Hays County	Hays* Same as the Groundwater RSA but extending north to San Marcos Springs
Mollusks				
False spike mussel *Quadrula mitchelli*	----	T	Possibly extirpated in Texas; probably medium to large rivers; substrates varying from mud through mixtures of sand, gravel and cobble; one study indicated water lilies were present at the site	Bexar, Blanco, Comal, Hays, Kendall Rio Grande, Brazos, Colorado, and Guadalupe (historic) River basins
Golden orb *Quadrula aurea*	P	T	Sand and gravel in some locations and mud at others; intolerant of impoundment in most instances	Bexar, Blanco, Comal, Hays, Kendall Guadalupe, San Antonio, and Nueces River basins
Texas fatmucket *Lampsilis bracteata*	P	T	Streams and rivers on sand, mud, and gravel substrates; intolerant of impoundment; broken bedrock and course gravel or sand in moderately flowing water	Bexar, Blanco, Comal, Hays, Kendall Colorado and Guadalupe River basins
Texas pimpleback *Quadrula petrina*	P	T	Mud, gravel and sand substrates, generally in areas with slow flow rates	Bexar, Blanco, Kendall Colorado and Guadalupe River basins
Crustaceans				
Peck's cave amphipod *Stygobromus pecki*	E/CH	E	Small, aquatic crustacean	Comal* Same as the Groundwater RSA but extending north to San Marcos Springs
Arachnids				
Braken Bat Cave meshweaver *Cicurina venii*	E/CH	----	Small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County	Bexar* Culebra Anticline Karst Fauna Region
Cokendolpher cave harvestman *Texella cokendolpheri*	E/CH	----	Small, eyeless, or essentially eyeless harvestman; karst features in north and northwest Bexar County	Bexar* Alamo Heights Karst Fauna Region
Government Canyon Bat Cave meshweaver *Cicurina vespera*	E	----	Small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County	Bexar Government Canyon and UTSA Karst Fauna Regions

Table 5-3: County of Occurrence and Resource Study Areas for Federal and State-listed Species

Species	Federal Status	State Status	Habitat	Counties/RSAs
Government Canyon Bat Cave spider *Neoleptoneta microps*	E	----	Small, eyeless or essentially eyeless spider; karst features in north and northwest Bexar County	Bexar Government Canyon Karst Fauna Region
Madla's Cave meshweaver *Cicurina madla*	E/CH	----	Small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County	Bexar* Stone Oak, UTSA, Helotes and Government Canyon Karst Fauna Regions
Robber Baron Cave meshweaver *Cicurina baronia*	E/CH	----	Small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County	Bexar* Alamo Heights Karst Fauna Region
Insects				
A ground beetle *Rhadine exilis*	E/CH	----	Small, essentially eyeless ground beetle; karst features in north and northwest Bexar County	Bexar* Stone Oak, UTSA, Helotes and Government Canyon Karst Fauna Regions
A ground beetle *Rhadine infernalis*	E/CH	----	Small, essentially eyeless ground beetle; karst features in north and northwest Bexar County	Bexar* Stone Oak, UTSA, Helotes, Government Canyon and possibly Culebra Anticline Karst Fauna Regions
Comal Springs dryopid beetle *Stygoparnus comalensis*	E/CH	----	Dryopids usually cling to objects in a stream; dryopids are sometimes found crawling on stream bottoms or along shores; adults may leave the stream and fly about, especially at night	That portion of the Groundwater RSA within Comal* County
Comal Springs riffle beetle *Heterelmis comalensis*	E/CH	----	Comal and San Marcos Springs	That portion of the Groundwater RSA within Comal* County
Helotes mold beetle *Batrisodes venyivi*	E/CH	----	Small, eyeless mold beetle; karst features in northwestern Bexar County and northeastern Medina County	Bexar* Helotes and Government Canyon Karst Fauna Regions
Fishes				
Fountain darter *Etheostoma fonticola*	E/CH	E	Known only from the San Marcos and Comal Rivers; springs and spring-fed streams in dense beds of aquatic plants	Comal, Hays, That portion of the Surface Water RSA associated with the Comal River
Toothless blindcat *Trogloglanis pattersoni*	P	T	Troglobitic; blind catfish endemic to the San Antonio Pool of the Edwards Aquifer	That portion of the Groundwater RSA in Bexar, and Comal Counties

Table 5-3: County of Occurrence and Resource Study Areas for Federal and State-listed Species

Species	Federal Status	State Status	Habitat	Counties/RSAs
Widemouth blindcat *Satan eurystomus*	P	T	Troglobitic; blind catfish endemic to the San Antonio Pool of the Edwards Aquifer	That portion of the Groundwater RSA in Bexar, and Comal Counties
Amphibians				
San Marcos salamander *Eurycea nana*	T/CH	T	Headwaters of the San Marcos River downstream to ca. ½ mile past IH-35; water over gravelly substrate characterized by dense mats of algae (Lyng bya) and aquatic moss (Leptodictym riparium)	Hays* Same as the Groundwater RSA but extending north to San Marcos Springs
Texas blind salamander *Eurycea rathbuni*	E	E	Troglobitic; water-filled subterranean caverns along a six mile stretch of the San Marcos Spring Fault, in the vicinity of San Marcos	Hays Same as the Groundwater RSA but extending north to San Marcos Springs
Blanco blind salamander *Eurycea robusta*	----	T	Troglobitic; water-filled subterranean caverns; may inhabit deep levels of the Balcones aquifer to the north and east of the Blanco River	Hays Same as the Groundwater RSA but extending north to San Marcos Springs
Cascade Caverns salamander *Eurycea latitans complex*	----	T	Endemic; subaquatic; springs and caves in Medina River, Guadalupe River, and Cibolo Creek watersheds within Edwards Aquifer	That portion of the Groundwater RSA in Bexar, Comal, and Kendall Counties
Comal blind salamander *Eurycea tridentifera*	P	T	Endemic; semi-troglobitic, found in springs and waters of caves	That portion of the Groundwater RSA in Bexar, Comal, and Kendall Counties
Reptiles				
Cagle's map turtle *Graptemys caglei*	----	T	Endemic; Guadalupe River System; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom, connected by deeper pools with slower flow rate and a silt or mud bottom; nest on gently sloping sand banks within 30 feet of water's edge	Comal, Hays, Kendall Guadalupe River Systems
Texas horned lizard *Phrynosoma cornutum*	----	T	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows in soil, enters rodent burrows, or hides under rock when inactive; breeds March-September	Texas Horned Lizard RSA Edwards Plateau Ecoregion

Table 5-3: County of Occurrence and Resource Study Areas for Federal and State-listed Species

Species	Federal Status	State Status	Habitat	Counties/RSAs
Texas indigo snake *Drymarchon melanurus erebennus*	----	T	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated croplands if not molested or indirectly poisoned; requires moist microhabitat, such as rodent burrows for shelter	Bexar Texas south of the Guadalupe River and Balcones Escarpment – not carried forward (South Texas species)
Texas tortoise *Gopherus berlandieri*	----	T	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; active March-Nov; breeds Apr-Nov	Bexar South Texas – not carried forward (South Texas team)
Timber/Canebrake rattlesnake *Crotalus horridus*	----	T	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover, i.e. grapevines or palmetto	Bexar Not carried forward – primarily East Texas species
Birds				
Bald eagle *Haliaeetus leucocephalus*	DL/M	T	Found primarily near rivers and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds	Blanco, Comal, Hays, Kendall Rivers and lakes in Texas —not carried forward (incidental)
Black-capped vireo *Vireo atricapilla*	E	E	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to the ground level for nesting cover; nesting season March-late summer	Bexar, Blanco, Comal, Hays, Kendall Rangewide with focus on Texas USFWS Recovery Region 3 and Land RSA counties
Golden-cheeked warbler *Dendroica chrysoparia*	E	E	Juniper-oak woodlands; dependent on Ashe juniper for long fine bark strips, only available from mature trees, only a few junipers or nearby cedar brakes are can provide nest material; nesting March-early summer	Bexar, Blanco, Comal, Hays, Kendall Rangewide with focus on USFWS Recovery Region 6 and Land RSA counties
Interior least tern *Sterna antillarum athalassos*	E	E	Nests along sand and gravel bars within braided streams, rivers; also known to nest on man-made structures (inland beaches, wastewater treatment plants, gravel mines, etc.)	Bexar, Kendall Rivers and streams with sand and gravel; lakes

Table 5-3: County of Occurrence and Resource Study Areas for Federal and State-listed Species

Species	Federal Status	State Status	Habitat	Counties/RSAs
Peregrine falcon *Falco peregrinus*	----	T	Occupies a wide range of habitats during migration including urban, concentrations along the coast and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands	Bexar, Blanco, Comal, Hays, Kendall Not carried forward (migrant)
White-faced ibis *Plegadis chihi*	----	T	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats	Bexar Wetlands and drainages within the Land RSA – not carried forward (incidental)
Whooping crane *Grus americana*	E	E	Potential migrant via plains throughout most of the state to coast; winters in coastal marshes of Aransas, Calhoun, and Refugio counties	Bexar, Blanco, Comal, Hays, Kendall Wetlands and drainages within the Land RSA in migration—not carried forward (migrant)
Wood stork *Mycteria americana*	----	T	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes with other wading birds	Bexar Wetlands and drainages within the Land RSA – not carried forward (incidental)
Zone-tailed hawk *Buteo albonotatus*	----	T	Arid open country, including open deciduous or pine-oak woodland, mesa or mountain country, often near watercourses, and wooded canyons and tree-lined rivers; nests in various habitats and sites ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in mountain regions	Bexar, Blanco, Comal, Hays, Kendall Rangewide within the US—not carried forward; breeding range outside AOI

E – Endangered; E/CH - Endangered with Critical Habitat designated within ICI study area
T – Threatened; T/CH- Threatened with Critical Habitat designated within ICI study area
C – Candidate for listing as threatened or endangered
P – Petitioned for Federal listing; USFWS has determined the species may warrant listing
DL – Federally De-listed; DM – Federally De-listed, monitoring
"---" – Not listed; rare, but with no current regulatory status
*** - counties with asterisks are noted on the USFWS site as containing Critical Habitat areas for that species**

Sources: U.S. Fish and Wildlife Service. 2011. Endangered Species List. List of Species by County for Texas: Bexar, Blanco, Comal, Hays and Kendall Counties. http://www.fws.gov/southwest/es/EndangeredSpecies/lists/ListSpecies.cfm, accessed May 5, 2010. Texas Parks and Wildlife Department. Annotated County Lists of Rare Species: Bexar County, last revision March 12, 2010; Blanco County, last revision March 12, 2010; Comal County, last revision March 12, 2010; Hays County, last revision March 12, 2010;and Kendall County, last revision March 12, 2010. http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx, accessed May 3, 2010.

5.3 STEP 3: DESCRIBE THE CURRENT STATUS/VIABILITY AND HISTORICAL CONTEXT FOR EACH RESOURCE

Step 3 of the cumulative effects analysis is intended to determine whether, in light of past developments and current conditions, these resources are healthy or at risk. The assessment of each identified resource or issue includes a discussion of general "diagnostic" indicators of the health of the resource, as suggested by CEQ (1997) guidance.

5.3.1 Land Resources

Historical Context: Land Use and Urban Development 1970-2010

Historically dominated by ranchlands and agricultural fields, the landscape of the Land RSA has begun to change in recent decades. The area has been transformed by commercial and residential development and the construction of supporting infrastructure. The Hill Country has also become an increasingly popular destination for river tubing and canoeing (Lyon 1983); the influx of tourists further taxes the area's resources and encourages development. By 2006, a significant portion of previously-untouched lands had been developed, placing traditional land uses and resources at risk for discontinued stability and eventual scarcity throughout the Hill Country.

Figure 4-3 in the previous chapter, **Indirect Effects**, graphically depicts the historical transformation of land uses in many areas of the Land RSA over the period 1983 to 2008. Based on aerial photography from 1983, 1996, and 2008, the map shows the sequence of development in the RSA in approximately 12-13 year intervals. The map clearly illustrates the increasing pace of development immediately adjacent to the US 281 project corridor, from Loop 1604 to Borgfeld Drive, especially during the most recent period (1996-2008). More sporadic but substantial development has occurred further north in the RSA in western Comal County. Further development in these areas has occurred since 2008, the last year of photographic depiction of development on **Figure 4-3.**

Health of the Resource: Current Land Use and Development Patterns in the Land RSA

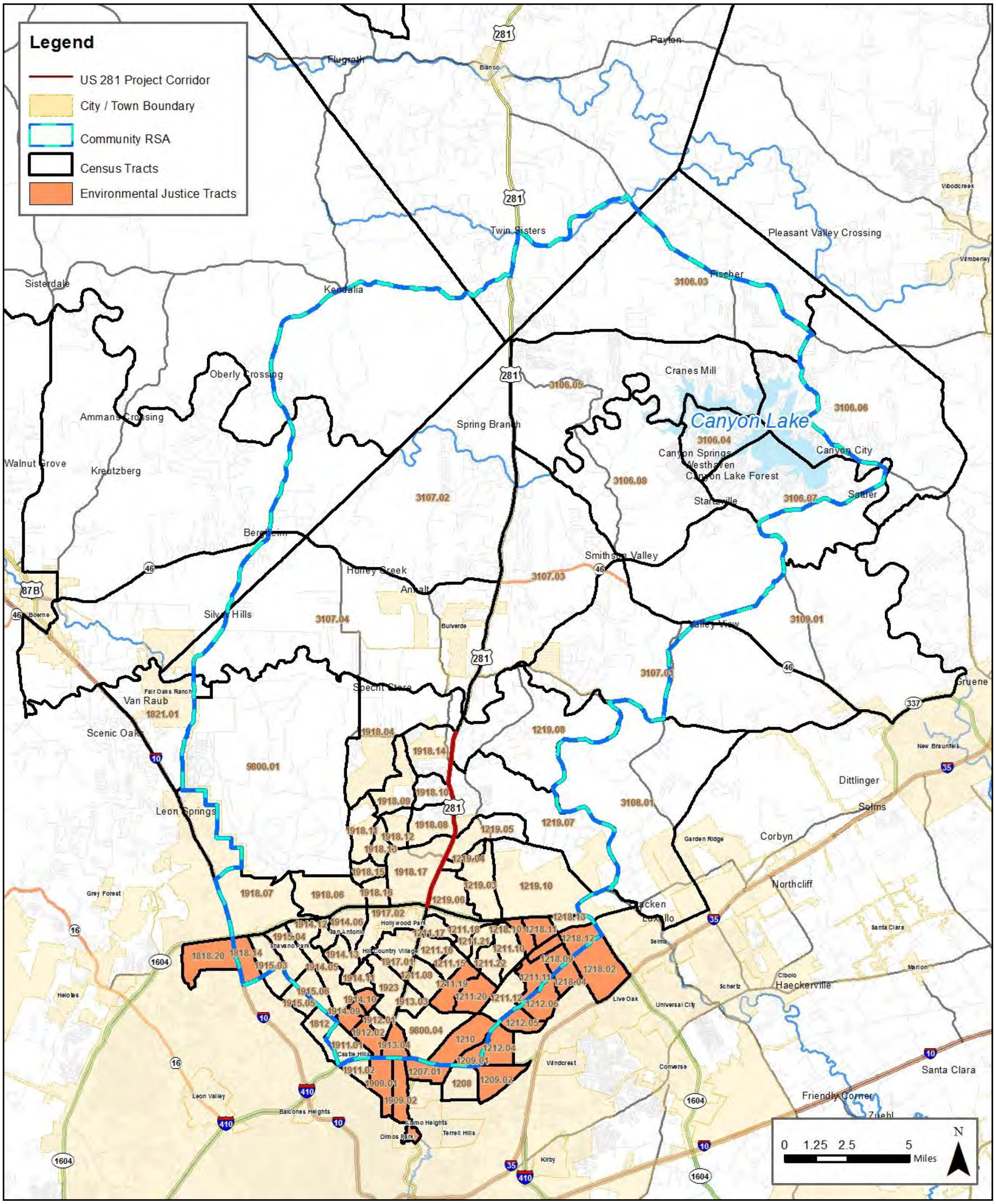
The status and viability of various land uses is reflected in the health of the resources that are dependent on the land, as detailed in the following sections.

5.3.2 Socioeconomic and Community Resources

This section presents information on the neighborhoods and communities in the Socioeconomic and Community RSA, including the demographic, economic, and social characteristics of the residents of those communities. The assessment addresses potentially vulnerable populations, and describes communities that might be affected by reasonably foreseeable future development in the RSA.

Figure 5-9 highlights the 2010 Census Tracts that roughly correspond to the Socioeconomic and Community RSA and highlight areas where Environmental Justice (EJ) populations have been identified.

Figure 5-9: Census tracts within or adjacent to the socioeconomic and community RSA



Source: US Census, Bureau, 2010 Census

Current Demographic Characteristics of the San Antonio Area

US Census Bureau 2009 survey data indicates that the median household income in the City of San Antonio was $42,731 and the median family income $51,715 (in 2008 inflation-adjusted dollars). Those figures for 2000 were $36,214 and $53,100, respectively. The per capita income for the city was $21,477 (in 2008 inflation-adjusted dollars), compared with $17,487 in 2000. Over 18.5 percent of individuals and 14.5 percent of families were below the poverty line (compared with 17 percent and 14 percent in 2000, respectively.) In the City of San Antonio in 2010, 72.6 percent of the population was White, 6.9 percent were Black or African American, 0.9 percent were American Indian and Alaska Native, 2.4 percent were Asian, 0.1 percent were Native Hawaiian and other Pacific Islander, 13.7 percent were another race, 3.4 percent were two or more races and 63.2 percent were Hispanic or Latino (of any race). In terms of the age distribution, 26.8 percent of the population in San Antonio were under 18 years of age, 26.9 percent were 50 years of age or older and 46.3 percent were between 18 and 49 years old. (US Census Bureau 2010a, 2010b, 2010c, 2010d).

Environmental Justice; Vulnerable Elements of the Population

TxDOT's (2010c) guidance document describes "Vulnerable Elements of the Population" to include "the elderly, children, persons with disabilities, minority groups, or low-income groups". These populations may be more susceptible to changes in the land use or transportation conditions in the environment. Based on the FHWA/TxDOT guidance for EJ, the SA-BC MPO has designated all Traffic Analysis Zones (TAZs) with populations exceeding 50 percent share minority or low-income as an EJ zone. EJ is discussed in more detail in **Section 3.4.3.**

Demographic data from the 2010 Census (detailed in **Appendix G)** shows that all Census Tracts (CT) with greater than 50 percent minority populations (i.e., populations other than non-Hispanic White) are located south of Loop 1604 in older more fully developed neighborhoods. None of the CTs north of Loop 1604 exceed 40 percent minority population. The highest median incomes in the RSA are in the tracts containing the newer subdivisions north of Loop 1604. Demographic characteristics of the RSA generally show a population with less racial or ethnic diversity and higher median income than the population of the City of San Antonio. These data indicate that there are readily identifiable EJ populations within the RSA.

Given the character of some communities as retirement areas, some enclaves of older people exist, possibly raising social, economic, and mobility issues in the future. Of the 93 tracts within the RSA, 50 percent or more of the population in six tracts is 50 years of age or older; they are located adjacent to Canyon Lake and south of Loop 1604. For example, CT 3106.04 which includes the south shore of Canyon Lake, has 21.1 percent aged 65 or older and more than 50 percent aged 50 or older. To address mobility issues for aging populations in the region, a number of local organizations have been created to address the transportation needs of older residents, including the Alamo Area Agency on Aging, Rainbow Senior Center & Foundation, Inc., serving Kendall County, and Comal County Senior Citizens' Foundation.

Toll and Managed Lanes Environmental Justice Analysis

According to *FHWA and TxDOT Joint Guidance for Project and Network Level Environmental Justice, Regional Network Land Use, and Air Quality Analyses for Toll Roads* (April 23, 2009), proposed toll facilities must undergo an evaluation to determine anticipated effects on EJ populations within the region, including the impacts to travel time and/or out-of-pocket cost. A project-level toll and managed lane EJ analysis is included in its entirety in **Appendix E** and a regional toll and managed lanes analysis is found in **Appendix F**.

Status and Viability of Communities in the Socioeconomic and Community RSA

Profile of the City of San Antonio

As noted in the **Chapter 4 Indirect Effects** and **Section 4.3.2** most of the Community RSA lies beyond the corporate limits of San Antonio, but the city and its growing economy continue to be the impetus for residential and commercial development into the northern suburbs. The growth patterns of the City of San Antonio are characteristic of other rapidly growing southwest urban centers where there are sparsely populated areas outside of the urban core. According to the 2010 Census, the City of San Antonio had a population of 1,327,407, ranking it the seventh-most populated city in the country and the second-most populated city in Texas. Due to San Antonio's increasing residential density surrounding the city limits, the metropolitan statistical area (MSA) has moved from the 30th most populated MSA in the U.S in 2000 to 25th in 2010. Subsequent population estimates indicate continued growth in the area. The population count for the eight-county San Antonio–New Braunfels has increased 25.2 percent between 2000 and 2010 with 2010 population of 2,142,508. The MSA is bordered to the northeast along IH-35 by the Austin–Round Rock–San Marcos MSA, and the two areas together combine to form a region of more than 3.8 million people. San Antonio was the fourth- fastest growing large city in the nation from 2000 to 2006 and the fifth-fastest-growing from 2007 to 2008.

San Antonio has a diversified urban economy with four primary focuses: financial services, government, health care, and tourism. Located northwest of the city center is the South Texas Medical Center, which is a conglomerate of various hospitals, clinics, and research centers, including the Southwest Research Institute and higher education institutions. The city is also home to one of the largest military concentrations in the United States. The defense industry in San Antonio employs over 89,000 people and provides a $5.25 billion impact to the city's economy. San Antonio has long had a strong military presence. Camp Bullis is located in the RSA; the city is also home to Fort Sam Houston, Lackland Air Force Base (AFB), Randolph AFB, and Brooks City-Base, and Camp Stanley outside the city. Kelly Air Force Base operated out of San Antonio until 2001, when the airfield was transferred over to Lackland AFB and the remaining portions of the base became Port San Antonio, an industrial/business park.

Twenty million tourists visit the city and its attractions every year, contributing substantially to the city's economy. The Henry B. Gonzalez Convention Center hosts more than 300 events each year, with over 720,000 convention delegates from around the world. According to a recent economic impact study conducted by the San Antonio Tourism Council, the City’s tourism industry employs 106,000 people, and brings in over $153 million in annual revenue, for an overall economic impact of over $11 billion per year (San Antonio Area Tourism Council 2008).

San Antonio is home to five Fortune 500 companies and to the South Texas Medical Center, the only medical research and care provider in the South Texas region (San Antonio Chamber of Commerce, 2010). Of the 140 Fortune Global 500 companies headquartered in the US, San Antonio is home to two: Valero Energy Corp, (ranked 33rd), and Tesoro Petroleum Corp, (ranked 317th). San Antonio's five Fortune 500 companies are Valero Energy Corp, Tesoro, USAA, Clear Channel Communications and NuStar Energy. H-E-B, the 19th largest privately held company in the United States, is also headquartered in San Antonio.

The strength of San Antonio's economic structure is its diversity, which is as varied as the city's cultural makeup. While traditionally known for its tourism/convention business and large military presence, San Antonio has shed its two-dimensional label and today has multiple industries driving its economy. As a result, the greater San Antonio area has one of the most robust economies in the country.

Profiles of Other Communities in the RSA

Research included in this section describes cities, communities, and other populated places within the Community RSA (identified on **Figure 5-2**) and includes available demographic, economic, historical, and cultural information from the identified sources as well as from field investigations, photography, citizen interviews, newspapers, guides, and other local references, as well as the City-Data website and the Texas State Historical Association's Handbook of Texas Online. Additional material was obtained through a Special Edition of *The Canyon Lake Views*, distributed by the Canyon Lake Chamber of Commerce (2010). Twenty-eight named populated places were investigated in greater detail. Some of these places were not confirmed as ongoing places of habitation. Others, like Fischer and Sisterdale, lie at the margin or outside of the Socioeconomic and Community RSA, or are established older neighborhoods in built-out areas of San Antonio, like Shavano Park or Castle Hills. As shown on **Figure 4-4**, the communities of Anhalt, Honey Creek, Rebecca Creek Road Neighborhood, Smithson Valley, and Spring Branch are located within likely induced development areas and are profiled in **Section 4.6.3**, Effects Related to Induced Growth. Other communities within the Community RSA are located within areas likely to be affected by reasonably foreseeable future development not related to the proposed US 281 project. These communities, profiled below, include Bergheim, Bulverde, Oak Cliff Acres, Silver Hills, Specht Store, and Timberwood Park.

Bergheim

Bergheim is located on SH 46 in eastern Kendall County southeast of city of Boerne, the county seat. German immigrants named the community Bergheim, meaning "mountain home," and moved into the area to cut native cedar for fence building and charcoal production. The Engel family opened the community's first general store prior to 1900, which was rebuilt in 1903. A cotton gin began operation in the area in 1900, and in 1901, the Bergheim post office was opened. The general store and post office were still in operation in 1990, supplying fence-building supplies, dry goods, feed, and grocery staples for farmers and ranchers from nearby towns such as Silver Hills, Bulverde West, Anhalt and Honey Creek. Adjacent services include a local diner and gas station. Bergheim had a reported population of 22 people between 1980 and 1990 (Gass 2011a).

Bergheim General Store and Post Office – FM3357 and SH46. The Bergheim General Store and Post Office serves as an important community resource for nearby farmers and ranchers.

Bulverde

Bulverde is located on Cibolo creek in southwestern Comal County 19 miles outside of New Braunfels. The town was originally named Pieper Settlement, after its settlement in 1850. Mail was delivered via Smithson Valley until a local post office, (named for early settler Luciano Bulverdo), opened, operating from 1879 to 1919. Beginning in 1959 Bulverde was served by a community post office located in Charles L. Wood's store. The town saw a decline in population in the 1960s when its population of 100 dropped to 25. The Bulverde school district consolidated with the Herrera, Ufnau, Honey Creek, Mustang Hill, and Green Hill schools and had a combined enrollment of 52 in 1947 (Haas 2011b).

In July 2007, Bulverde's population was 5,003. The median resident age is 39.8 years, and the estimated median household income in 2008 was $89,527 (it was $67,055 in 2000). The estimated per capita income in 2008 was $34,851 (City-Data 2010).

Oak Cliff Acres

Oak Cliff Acres is a residential community located on State Highway 46 about 24 miles west-northwest of New Braunfels in western Comal County. Development in the area probably began by the 1980s. No population figures were available in 2000 (Jasinski 2011c).

Silver Hills

Silver Hills is located at FM 2251 and Silver Hills Drive three miles south of Bergheim. There are no known commercial facilities, and only scattered houses and ranches were observed from field research.

Specht Store

The community of Specht Store is located on the Bexar-Comal County line approximately 21 miles north of San Antonio. The store was opened in 1900 by the Specht family and, by the 1930s, the community also included a number of houses. In 2003, the community consisted of several residences and a restaurant, which also served as a store, bar, and music venue. (Long 2011).

Timberwood Park

Timberwood Park is located 21 miles north of San Antonio, off of US 281. Development began in the 1980s, and by 1990, Timberwood Park had a population of 2,578. By 2000, the population was 5,889 residents (Jasinski, 2011d). The growth rate has slowed in the last decade, with 2007 population reported at 6,699. Timberwood Park's residents are older in comparison to San Antonio and the state, with a median age of 37.8 years. The estimated median household income in 2008 was $94,413 (it was $79,053 in 2000), compared with the state's median household income of $50,043. The estimated per capita income in 2008 was $42,442 (City-Data 2010).

Bulverde Community Park- Bulverde Ln and FM 1863 Land is designated for large social/community organizations and activities.

Spechts Store- Obst Rd and W. Specht Rd. Viewed as a cultural icon for residents of Bulverde and nearby communities. Famous for its food and attraction to local musicians for weekly "open mic" night.

Timberwood Park

Timberwood Park- Timberline Dr. and Misty Water Lane. Designated as a member/resident-only park in the Timberwood neighborhood. Live music is held every other Friday, several other community events are held every month.

5.3.3 Water Resources – Surface Water

Resource Overview

The Surface Water RSA is traversed by portions of two of Texas' major river basins - the San Antonio to the south and the Guadalupe to the north (**Figure 5-3**). Major streams in these two river basins within the Surface Water RSA include: Salado Creek, the Upper San Antonio River, the Guadalupe River, the Little Blanco River, the Blanco River, Dry Comal Creek, and Cibolo Creek. The Surface Water RSA contains 28 named watersheds and 8 named rivers (USDA/NRCS 2010; USGS 2010).

Some of the rivers and streams in the watersheds discussed above have the potential to be directly or indirectly impacted by each of the Proposed Build Alternatives for the US 281 Corridor Project. In addition, some of these streams may also be affected by water quality effects associated with past, present and reasonably foreseeable future land development activities.

The Blanco River, within the Guadalupe River Basin, is an 87-mile long river that drains the northern part of the Surface Water RSA. The Blanco River watershed drains the northeastern part of Kendall County and traverses southern Blanco County, the northern part of Comal County and central Hays County before joining with the San Marcos River.

The Guadalupe River has its headwaters on the western side of Kerr County. The river enters the Surface Water RSA as it winds along a generally eastward path through Kendall and Comal Counties, turning south-southeast to the city of New Braunfels at the edge of the Surface Water RSA. The Guadalupe River is dammed to form Canyon Lake reservoir in the northeast portion of the Surface Water RSA. The Guadalupe River and Canyon Lake are considered high value surface water resources within the Surface Water RSA; Canyon Lake reservoir provides flood control as well as regional water supply, and the upper and middle segments of the Guadalupe River are notable for high quality aquatic habitat. The river is home to a variety of aquatic species such as bass, catfish, turtles, salamanders, mussels and beetles. It is home to the official state fish of Texas, the Guadalupe bass (*Micropterus treculii),* as well as other game species including the largemouth bass, (*Micropterus salmoides*). The Texas Parks and Wildlife Department seasonally stocks the Guadalupe River with rainbow trout (*Oncorhynchus mykiss*). Both the Guadalupe River and Canyon Lake offer many kinds of recreation including camping, picnicking, trails, boating and paddle sports, fishing, tubing, and swimming. Fed by the natural discharge of the Edwards Aquifer, exemplified by Comal Springs and San Marcos Springs, the Guadalupe River is a major year-round source of freshwater to San Antonio Bay and other portions of the Guadalupe estuarine system.

Cibolo Creek, a tributary of the San Antonio River, flows approximately 96 miles (154 km) from its source upstream of Boerne in Kendall County, to its confluence with the San Antonio River in Karnes County. It forms a part of the county line between Bexar, Comal, and Guadalupe Counties. Cibolo Creek is a major recharge feature of the southern segment of the Edwards Aquifer.

The San Antonio River originates from several springs in north central San Antonio and converges with the Guadalupe River in Victoria County just upstream of San Antonio Bay and the Guadalupe estuarine system. The city of San Antonio is a major feature dominating the landscape of the upper San Antonio River watershed. The main tributaries to the San Antonio River are the Medina River, Leon Creek, Cibolo Creek and Salado Creek. The river becomes a primary conduit for treated wastewater effluent downstream of San Antonio, and this is an important component of the overall water regime that supplies freshwater inflows to the ecologically important estuary.

The Surface Water RSA contains surface water features considered jurisdictional waters of the United States and are subject to regulation by the US Army Corps of Engineers (USACE) for certain activities that occur within the jurisdictional limits. Types of waters of the US within the Surface Water RSA include rivers, streams (including perennial, intermittent, and ephemeral), reservoirs, ponds (including stock tanks connected to other jurisdictional waters), and wetlands. The jurisdictional area of rivers and streams is defined as that portion of the waterbody that is below the ordinary high water mark (OHWM). Wetlands are jurisdictional waters that are defined as areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that normally do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Thus, jurisdictional wetlands are generally delineated based on a site-specific field investigation to determine the presence of soil, hydrologic and vegetation indicators of wetland conditions; such site-specific delineations are appropriate for evaluation of direct effects.

Streams within the Surface Water RSA have developed on the moderate to steeply rolling hills of the Edwards Plateau, which is characterized by hillsides that are highly dissected by numerous stream channels. Jurisdictional waters of the US within the Surface Water RSA include the named and unnamed ephemeral creeks and drainages that transport runoff during rain events and have drainage areas large enough to form channels that are bounded by an identifiable OHWM. These ephemeral streams transport water to larger, seasonally intermittent creeks. Surface flow eventually ends up in the larger streams of either the Guadalupe or San Antonio River Basin. Some of these streams are important storm runoff conduits that contribute recharge to the Edwards Aquifer via their stream beds. Freshwater ponds, also called stock tanks, within this region may not be considered jurisdictional if they are off-channel and not connected to a water of the US. A field delineation confirming wetlands or other jurisdictional waters of the US is required for any permitting situation, where direct effects are considered.

Floodplains within the Surface Water RSA may be classified according to the Federal Emergency Management (FEMA) zones A, AE, X, and X500, which are relevant to the flood insurance program and are defined based on the probability of flooding. The 100-year flood elevations and flood depths provided on Flood Insurance Rate Maps (FIRMs), where available, establish the minimum regulatory elevations applicable to local floodplain management ordinances. Zones A and AE generally correspond to the areas subject to a 100-year flood event. The approximate 100-year floodplains are depicted as part of the land development constraints shown on **Figure 4-7**. Zone A is defined by FEMA as areas with a one percent annual chance of flooding. Zone A designations are considered approximations where detailed analyses have not been performed, thus no depths or base flood elevations are determined for these zones. Zone AE designates areas with a one percent annual chance of flooding where the base flood elevations have been determined. Zone X defines areas of moderate flood hazard, usually the area between the limits of the 100-year and 500-year floods. Zone X500 generally refers to areas subject to a 500-year flood event. Most lands within the Surface Water RSA are classified as Zone X, with floodplains classified as Zones A and AE found alongside rivers and streams.

Historical Context

The geographic location of streams within the moderate to steeply sloping hills of the Edwards Plateau in association with the region's weather patterns has resulted in streams with large variability of flow. According to the USGS, Texas leads the nation in flash flood fatalities, and the state holds about half of the world record rainfall rates occurring in 48 hours or less. The National Weather Service has identified South Central Texas as one of the most flash-flood prone areas in the United States. Both the geography and geology of the South Central Texas region allow for the formation of severe storms that can stall and produce torrential rain. For this reason, South Central Texas is known as "Flash Flood Alley." Increased development along stream corridors and within floodplains change the dynamics of flood flows and associated levels of risk over time. While too much precipitation over a short time period can lead to flooding effects, the surface water regimes of the region also include periodic droughts, which put a stress on both aquatic life and human uses of surface water and lead to increased reliance on groundwater supplies at a time when aquifer levels are falling. The effect of drought on surface-groundwater interactions is discussed further below.

Status/Viability

As noted in **Section 4.3.4**, the Blanco River and its tributary Carpers Creek along with the Upper Guadalupe River and its tributary Honey Creek are designated by the TPWD as Ecologically Sensitive River and Stream Segments in the South Central Texas Water Planning Region (Norris et al. 2005). In its assessment of aquatic conservation targets within the Edwards Plateau ecoregion, The Nature Conservancy (TNC) identified the aquatic systems Blanco River, upper and middle segments of the Guadalupe River, Honey Creek, San Antonio River headwaters/Salado Creek and Leon Creek as well as several of their endemic, globally at-risk aquatic wildlife, including species of fish, salamanders, mussels and the Cagle's map turtle (The Nature Conservancy 2004). This ecoregion assessment identified streams that are currently considered to be high quality aquatic ecosystems as well as those that are currently degraded. It also identified threats to each of the aquatic conservation targets.

The following aquatic system threats were identified by TNC ecoregion assessment: residential development, groundwater manipulation, fire management, and grazing practices were listed as common threats to the Blanco River, Guadalupe River, Leon Creek, and San Antonio River headwaters/Salado Creek); fire management and grazing practices were listed as the threats to Honey Creek; tree clearing for improved streamflow was identified as an additional threat to the Blanco River system; channelization and commercial/industrial development were identified as additional threats to Leon Creek and the San Antonio River headwaters/Salado Creek; and military activities were identified as an additional threat to the Leon Creek aquatic system. A more focused current project on the Blanco River identified stresses that include unsustainable ground and surface water use (The Nature Conservancy 2010). At the landscape scale, TNC identified the proximate causes of changes in the functions of ecosystems and the distribution and composition of biological communities of the Edwards Plateau ecoregion; land conversion, water use patterns, modification of natural fire regimes, exotic species introductions and landscape fragmentation were identified as having had major impacts (The Nature Conservancy 2004).

The health of streams and rivers is dependent on the quality of water entering them from runoff and baseflows, the stability and variability of baseflow regimes, and the volume, timing and intensity of storm flows that have the potential to alter stream channel morphology and habitat. The volume of surface water available to satisfy increasing human demand as well as ecological functions depends on a number of variables: the amount of precipitation falling on the watershed and associated runoff into the streams; the amount of water discharged to streams by springs and seeps and lost by the streams as they pass over porous aquifer recharge zones; retention from on-channel and off-channel reservoirs; frequency and duration of releases from on-channel dams; and the volume of surface water withdrawals for agricultural, municipal, industrial, and other purposes. Spring ecosystems, although considered a surface water resource, are integrally linked to groundwater levels and are discussed in the groundwater section below. Increasing demand for various water uses has resulted in changes in stream flow from the exercise of allocated water rights. The need for additional water supply has been identified to satisfy future demand for water in the region. If additional water supplies cannot be developed to address future water demand, then it is possible that an increased demand on existing surface water supplies could occur. This could result in a decline of instream flows.

The status of biological communities is a good indicator of overall water resource health because resident aquatic life must integrate the effects of a variety of water quality and habitat conditions. Likewise, the presence of at-risk aquatic species is indicative of stressors that may be manifest at the watershed or drainage basin scale, and which have already caused an impact. Resource protection programs are necessarily reactive in situations where prevention or avoidance of impacts was not achieved. For example, 15 species of freshwater mussels (mollusks) were state-listed as threatened in Texas in November 2009 based on identified threats to occupied habitat, declining abundance, and existing rarity. Nine of these Texas freshwater mussel species have been petitioned for federal listing. A federal listing status would present major implications for future projects that could affect rivers and streams where these mussel species occur. Four of the state-listed mussels may occur in waters of the Surface Water RSA. The state list of threatened aquatic species also includes the Cagle’s map turtle that inhabits the Guadalupe River basin, and two salamander species that inhabit spring and cave waters within the Surface Water RSA, at the interface between ground and surface waters where they may be affected by the conditions of surface water flows and quality.

Freshwater Inflows to the Guadalupe Estuarine System

Even though San Antonio Bay and the Guadalupe River estuary are located far downstream, water management within the Surface Water RSA may affect the estuary. Estuarine systems depend on a certain range of freshwater inflow regimes to maintain suitable conditions for resident and migratory aquatic life. For some species, maintaining salinity gradients are particularly important. During drought periods when freshwater inflows are greatly reduced, there is an increased potential for estuarine ecology to become stressed. The importance of maintaining suitable levels of freshwater inflows to the Guadalupe Estuarine system has been recognized by regional groundwater and surface water management plans (Edwards Aquifer Authority (EAA) 2003; SCTRWP 2009 and 2010), and by public interest groups (League of Women Voters of Comal Area [LWV-CA] 2005).

Surface Water Quality

As discussed in **Section 4.2.2**, the surface waters of the northern portion of the Surface Water RSA, including the mainstems and tributaries of the Upper Guadalupe River, Canyon Lake, and the Blanco River, are generally characterized by high quality waters and healthy aquatic habitat, except in localized cases of degradation. An example of localized water quality degradation is the upper Guadalupe River in the Kerrville area, upstream of the Surface Water RSA, where elevated levels of pathogen-indicator bacteria were traced to watershed sources of contamination, including on-site wastewater systems, urban runoff, wildlife and livestock sources. Canyon Lake has historically been one of the clearest and cleanest reservoirs in Texas; however, as discussed in **Section 4.2.2**, a trend towards eutrophication, or nutrient enrichment of the reservoir, is indicated over the past decade according to indicators of algal biomass and other measures assessed by the TCEQ (2008). Streams in the central and southern portions of the Surface Water RSA are characterized by water quality and aquatic habitat conditions that reflect a range of impacts or degradation that vary according to the level of residential and other urban land development within their drainage areas. For example, water quality assessments have identified impaired sections of Cibolo Creek in both its upstream and downstream reaches within the Surface Water RSA. The upstream area is affected by inputs of bacteria and nutrients and by habitat alterations, likely associated with rapid growth and land use changes in the Boerne area, while the downstream Mid Cibolo segment is affected by urbanized north San Antonio and neighboring cities.

303(d) List of Impaired Streams and TMDLs

TCEQ conducts a statewide inventory of surface water quality conditions that is reported every two years in compliance with Section 305(b) of the Clean Water Act. As a part of this statewide assessment process, the Clean Water Act 303(d) list is prepared by the TCEQ to identify impaired surface waters that are considered to be water-quality limited. The listing is a determination that effluent limitations that may apply to individual sources are not considered to be sufficient to achieve water quality standards for certain listed pollutants, and therefore the listed pollutants should be addressed by maximum daily load. Total Maximum Daily Load (TMDL) studies are then conducted and implemented according to a certain priority determined by the TCEQ. Once a TMDL is approved, a waterbody may be delisted for the pollutant addressed by the TMDL, as was the case in the example of the Upper Guadalupe River bacteria impairment discussed earlier.

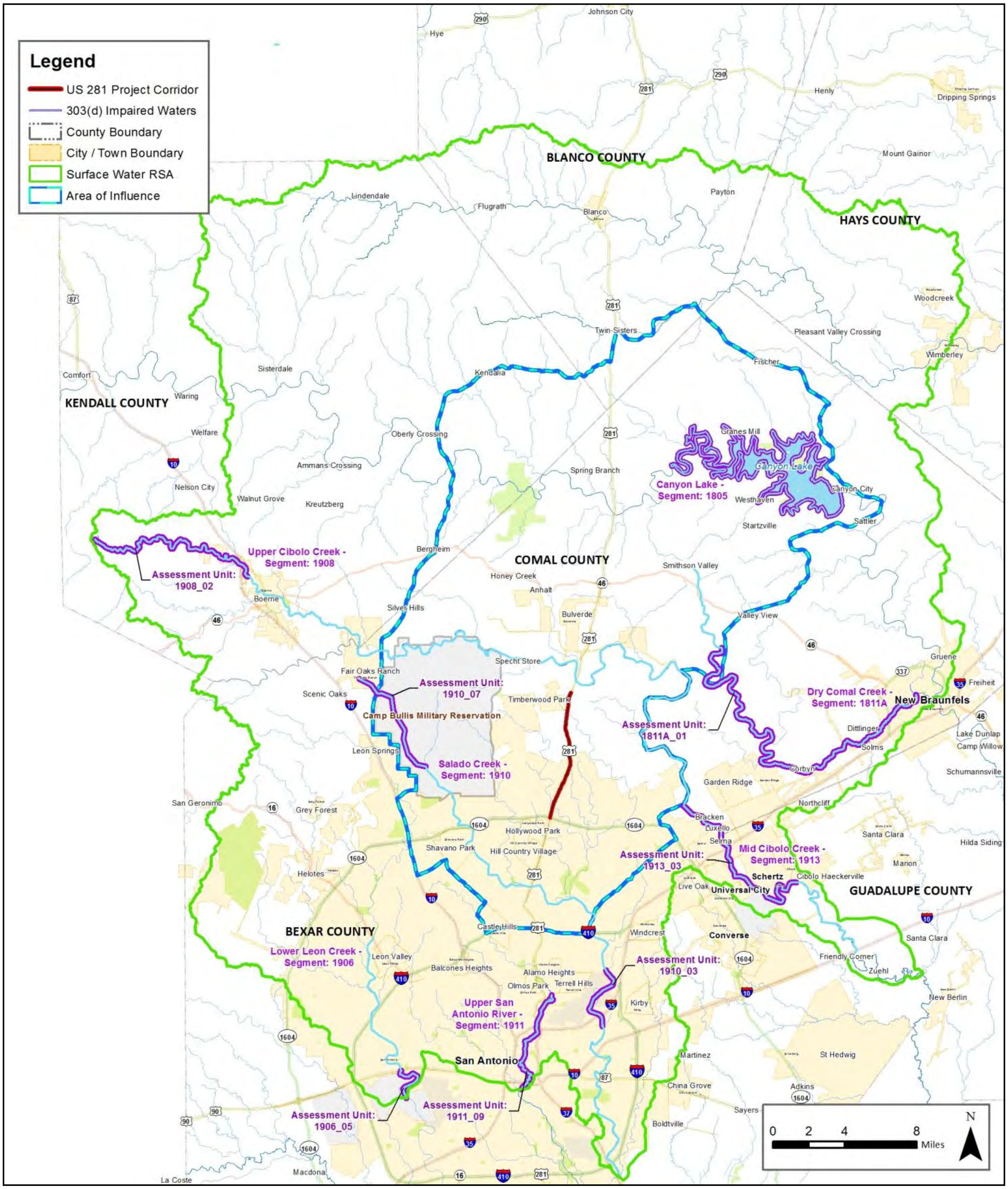
The TCEQ's Approved 2010 303(d) List identifies specific portions of six TCEQ-designated surface water segments within the Surface Water RSA: Canyon Lake (Segment 1805), Upper Cibolo Creek (Segment 1908), Mid Cibolo Creek (Segment 1913), Salado Creek (Segment 1910), the Upper San Antonio River (Segment 1911), Lower Leon Creek (Segment 1906), and Dry Comal Creek (Segment 1811A).

These segments are shown in **Figure 5-10**, and are briefly summarized below.

- Canyon Lake is listed for having mercury in edible tissue; the sources of contamination are listed by the TCEQ as atmospheric deposition and unknown sources.
- Upper Cibolo Creek is listed for bacteria contamination upstream of Boerne; the sources of contamination are indicated by the TCEQ to be unknown point and nonpoint sources.

- Mid Cibolo Creek is listed for bacteria contamination in the upper portion of the segment; the sources of contamination are indicated by the TCEQ to be unknown point and nonpoint sources. A previous listing of depressed dissolved oxygen levels in Mid Cibolo Creek was removed from the 2008 303(d) List because the TCEQ expects the creek to meet standards following recent upgrades of a permitted facility.
- Salado Creek is listed for having an impaired fish community and an impaired macrobenthic community in two different portions of the creek. A previous listing for bacteria contamination in Salado Creek was removed from the 2008 303(d) List because a TMDL has been approved by the TCEQ to address this impairment. The sources of impairment are indicated by the TCEQ to be unknown point and nonpoint sources.
- Upper San Antonio River is listed for having an impaired fish community in one assessment unit. A previous listing for bacterial contamination in the Upper San Antonio River was removed from the 2008 303(d) List because a TMDL has been approved by the TCEQ to address this impairment. The sources of impairment are indicated by the TCEQ to be unknown point and nonpoint sources.
- Lower Leon Creek is listed for bacteria, depressed dissolved oxygen, and polychlorinated biphenyl (PCBs) in edible fish tissue. The sources of impairment are indicated by the TCEQ to be unknown point and nonpoint sources.
- Dry Comal Creek was added to the 303(d) list in 2010 due to bacterial contamination affecting the lower 25 miles of the stream. The upper approximately 2.5 miles of this impaired section are within the AOI. TCEQ lists the pollution source as unknown.

Figure 5-10: Impaired surface waters according to TCEQ 2010 303(d) list within the surface water resources study area



Source: US 281 EIS Team, 2012

As summarized above, the TCEQ has not identified specific sources or more specific categories of sources for the listed impairments, but rather has indicated unknown point sources and/or unknown non-point sources, except that atmospheric deposition is indicated as a source of mercury in Canyon Lake fish tissue. The US Environmental Protection Agency (EPA) defines point source pollution as "any single identifiable source of pollution from which pollutants are discharged," such as a pipe or ditch. Non-point source pollution results from runoff that collects one or more pollutants as it passes over contaminated land, and in particular, impervious surfaces in the watershed, and includes surfaces contaminated by atmospheric deposition. This runoff eventually infiltrates into groundwater or enters a surface water stream. Both point and non-point source pollution increase with population growth and land development.

Potential for Water Quality Impacts from Spills

Wastewater spills can occur if sewer lines crack or break, sewer manholes leak, lift stations overflow, or effluent treatment or storage basins are flooded. Wastewater spills are often associated with extreme rainfall and streamflow events. The amount of wastewater released can vary by orders of magnitude. If over or upstream of an aquifer recharge zone, the wastewater spill could contaminate groundwater as well as surface water. The largest wastewater utility in the Surface Water RSA, the San Antonio Water System (SAWS) has experienced wastewater spills of various magnitudes, including a recent (January 2010) 150,000 gallon sewer overflow spill over a portion of the Edwards Aquifer Recharge Zone in north central San Antonio that was apparently caused by sewer line blockage by construction debris, and a 15 million gallon spill in October 2002 from a sewer main break caused by excessive erosion that exposed lines in lower Salado Creek.

Accidental release of hazardous materials has occurred over the Edwards Aquifer Recharge Zone. In 2000, 2,692 gallons of diesel fuel leaked from a 10,000-gallon above ground storage tank at a limestone quarry near New Braunfels. Around 2,000 cubic yards of contaminated soil and rock were dug up from the site. Investigators believe all the diesel was removed with the soil. Water wells at the quarry, Comal Springs, and public water wells in New Braunfels were sampled. There is no indication that any of the spilled diesel fuel reached the Edwards Aquifer.

5.3.4 Water Resources – Groundwater

Resource Overview

Groundwater resources include the Edwards (Balcones Fault Zone) and Trinity Aquifers. Portions of both aquifers are located in the southeastern portion of the Edwards Plateau Physiographic Province of Central Texas, along the Balcones Fault Zone and in the upland Hill Country.

Edwards (Balcones Fault Zone) Aquifer

The Edwards Aquifer is the primary source of water for a large portion of Central Texas, including approximately 1.7 million people (EAA 2009; US Census Bureau 2010b). It supports cities, towns, rural communities, farms, and ranches. The water is used for a range of purposes, including municipal, industrial, manufacturing, steam electric, irrigation, mining, livestock, and recreational uses.

The Edwards Aquifer is considered a karst aquifer. Flow in karst aquifers occurs over a wide range of hydraulic conductivity, from flow through the rock matrix (least conductive), flow in planar fractures and bedding planes, to turbulent flow through integrated conduit systems (most conductive). In general, most storage occurs in the matrix, while most flow occurs in the fractures/faults and conduits. Matrix and conduit components may or may not mix effectively. Thus, groundwater in some components of the aquifer may have very long residence times and be relatively resistant to surface contamination, while other components of the aquifer may have extremely rapid travel times and be very vulnerable to contamination. The vulnerable parts of the aquifer include discrete recharge features and also the most productive zones, feeding major springs and wells.

In addition to the range of flow velocities, flow directions are also variable in karst aquifers. Flow directions are influenced by both regional and local hydraulic gradients, but they are also controlled by the location and orientation of conduit systems. Karst aquifers may be influenced by development and changes in geologic formations that occurred under previous water flow regimes; thus flow paths may not follow local topography or surface watersheds. It is common for flow in karst aquifers to cross watershed boundaries, which are typically considered to be groundwater divides in other types of aquifers. Furthermore, the pattern and direction of flow in karst aquifers is often water-level dependent, as high water levels can utilize older flow paths and travel in non-linear directions using conduits formed under older groundwater regimes, which may differ from modern ones.

The Edwards Aquifer occurs in rocks of the Edwards Group, which include the Kainer and Person Formations. Geographically, the Edwards (Balcones Fault Zone) Aquifer is divided into three segments: the San Antonio Segment, the Barton Springs Segment, and the Northern (Balcones) Segment. The San Antonio Segment is pertinent to the Groundwater RSA and stretches from central Kinney County in the west to central Hays County in the northeast. The San Antonio Segment is separated from the Barton Springs Segment by a groundwater divide running west-northwest from the city of Kyle, in Hays County. Generally, groundwater north of the divide flows north, while groundwater south of the divide flows south. To the northwest, the San Antonio Segment is bounded by the Trinity Aquifer, and to the south and southeast it is bounded by less permeable, younger rocks down thrust by the Balcones Fault Zone. The freshwater/saline water interface (bad water line) delineates the aquifer’s eastern and southern boundaries. The bad water line is not a well defined boundary but rather a transition zone on the southern and eastern limits of the aquifer. The Edwards Aquifer is divided into the following management areas by the TCEQ under the Edwards Aquifer Protection Program: Contributing Zone, Recharge Zone, Transition Zone, and Confined Zone. The Contributing and Recharge Zones are located within the Groundwater RSA.

The Contributing Zone is composed of drainage areas and catchments of surface streams upstream of and subsequently flowing over the Recharge Zone. Much of the Contributing Zone lies over the older Glen Rose Formation, upthrust by the Balcones faulting. The Recharge Zone is a relatively narrow band of Edwards Group limestone outcrops that is heavily faulted and karstified, including the overlying Georgetown Formation. In the Recharge Zone, surface water flows into the ground through recharge features, which include named creeks and streams that pass over the Recharge Zone. Recharge in water impoundments creates high hydraulic gradients and discrete recharge features such as caves, pits, and sinkholes. Water stored in the Recharge Zone is unconfined since no low-permeability zone (aquitard or aquclude) overlies it. Water flows are driven by gravity to discharge at water-table springs, to enter deeper flow systems and discharge at artesian springs, or to recharge the Confined Zone of the aquifer, which is that portion covered by other formations younger in geological age. The Transition Zone consists primarily of younger bedrock overlying the Confined Zone of the Edwards Group that has been down thrust to the east in the Balcones Fault Zone. These younger and generally less permeable rocks of the Transition Zone overlie and form the upper units to the Confined Zone of the Edwards Aquifer. While the surface bedrock in the Transition Zone is generally less permeable and karstified than the rocks of the Edwards Group, it was also extensively fractured and faulted by the Balcones Fault Zone and hosts some high-permeability pathways into the Confined Zone. An exception is the Austin Chalk formation, which is well karstified in some areas and hosts significant springs that discharge Edwards Aquifer water, such as San Antonio and San Pedro Springs (Veni and Heizler 2009).

Trinity Aquifer

The Trinity Aquifer covers a large portion of Central Texas, which is bounded to the east and south by the Edwards Aquifer; to the west has presumed flow paths between the Trinity and the Edwards-Trinity Aquifers; and to the north by variations in bedrock geology and deeply incised rivers.

The Trinity Aquifer is located within lower Cretaceous rocks underlying the Edwards Group, including the Hosston Formation, the Sligo Limestone, the Hammett Shale, the Cow Creek Limestone, the Hensel Sand and the Glen Rose Formation (Ashworth 1983). The Trinity Aquifer is divided into three units based on hydrogeologic differences (Upper, Middle, and Lower Trinity) that form a leaky, primarily confined aquifer system (Ashworth 1983).

Stratigraphically, it is divided as follows: the Lower Trinity in the Sligo Limestone and the Hosston Formation, the Middle Trinity in the Cow Creek Limestone, the Hensel Sand in the lower member of the Glen Rose Formation, and the Upper Trinity in the upper member of the Glen Rose Formation. The Upper and Middle Trinity Aquifers are pertinent to the Groundwater RSA.

Caves and karst features are known from both the Cow Creek Limestone and the Glen Rose Formation (Veni 1997). In the Groundwater RSA, the Middle Trinity Aquifer ranges from 60 to 200 meters thick (Mace et al. 2000) and discharges through springs, pumping directly into the Edwards Aquifer to the south and east. The lower member of the Glen Rose Limestone contains more secondary porosity than the upper member (Ashworth 1983; Veni 1997).

In the Groundwater RSA, the Upper Trinity Aquifer occurs in the upper member of the Glen Rose Formation and ranges from zero to 120 meters thick (Mace et al. 2000). The rocks of the upper member of the Glen Rose Formation are composed of alternating units of limestone and shale and form part of the Contributing Zone for the Edwards Aquifer and are significantly karstified in areas, including the largest tourist cave in the region, Natural Bridge Caverns in northwestern Comal County. The rocks of the upper Glen Rose often form part of the Contributing Zone for the Edwards Aquifer. Much of the Upper Trinity groundwater emerges in seeps and springs. Some of this discharge flows overland and is recharged into the Edwards Aquifer. Recent dye-trace studies have indicated that the amount of groundwater migrating from the Trinity Aquifer to the Edwards Aquifer is greater than previously thought (Green 2011). Some Upper Trinity groundwater flows into the underlying Middle Trinity Aquifer. In addition to relatively low permeability, the upper member of the Glen Rose Formation is easily eroded and, when exposed at the surface, is likely to be discontinuous, which inhibits its function as an aquifer. The quantity of Trinity Aquifer groundwater is variable throughout the RSA, and the aquifer is used as a water supply in some areas of northern Bexar and northwestern Comal Counties. Yields in the Trinity Aquifer are up to 250 times lower than in the Edwards Aquifer (Mace et al. 2000).

Historical Context

The issue of extracting groundwater for public and private use in the San Antonio region while also maintaining substantial flow to Comal and San Marcos Springs is contentious. During the peak of the drought of record in 1956, Comal Springs ceased flowing for about 144 days. In recent years, substantially more pumping has occurred, creating increased risk to the spring ecosystems when extreme droughts occur.

The Texas Legislature created the Edwards Aquifer Authority (EAA) by passage of the Edwards Aquifer Authority Act to "manage, conserve, preserve, and protect the southern segment of the aquifer and to increase the recharge of, and prevent pollution of water in, the aquifer." Although the legislation was passed in 1993, litigation delayed agency start-up by three years, until 1996. In 2007, the Texas Legislature mandated the EAA to allow regular permitted withdrawals from the southern segment of the Edwards Aquifer of up to 572,000 acre-feet per year subject to mandatory reductions in pumping of up to 40 percent during critical drought periods. These mandates may be further modified by aquifer management strategies currently being developed as part of a Habitat Conservation Plan, mandated in 2007 by the Texas Legislature as part of the Edwards Aquifer Recovery Implementation Program (EARIP).

The dynamics of Edwards Aquifer water levels and associated flows of Comal and San Marcos Springs are affected by the rate of water entering the aquifer (recharge) and the rate of water exiting the aquifer (discharge). Decreased spring discharge can adversely affect the health of eight federally-listed endangered or threatened species that depend on adequate minimum flows at Comal and San Marcos Springs for survival. Because of the regional importance of the Edwards Aquifer, the dynamics of aquifer recharge and discharge, including ways to enhance recharge, have been subjects of considerable study, and the state of knowledge about aquifer dynamics is improving and evolving.

Edwards Aquifer Recharge

The Recharge Zone comprises approximately 1,250 square miles of Edwards Limestone exposed at the ground surface (**Figure 5-4**). Recharge occurs from water entering the Recharge Zone from streams, natural catchments, recharge structures, and localized runoff from precipitation events. Streams flow south and east from the drainage area (the Texas Hill Country) and lose all or most of their base flow as they cross the Recharge Zone. Seasonal rainfall over the region ultimately controls the rate of recharge.

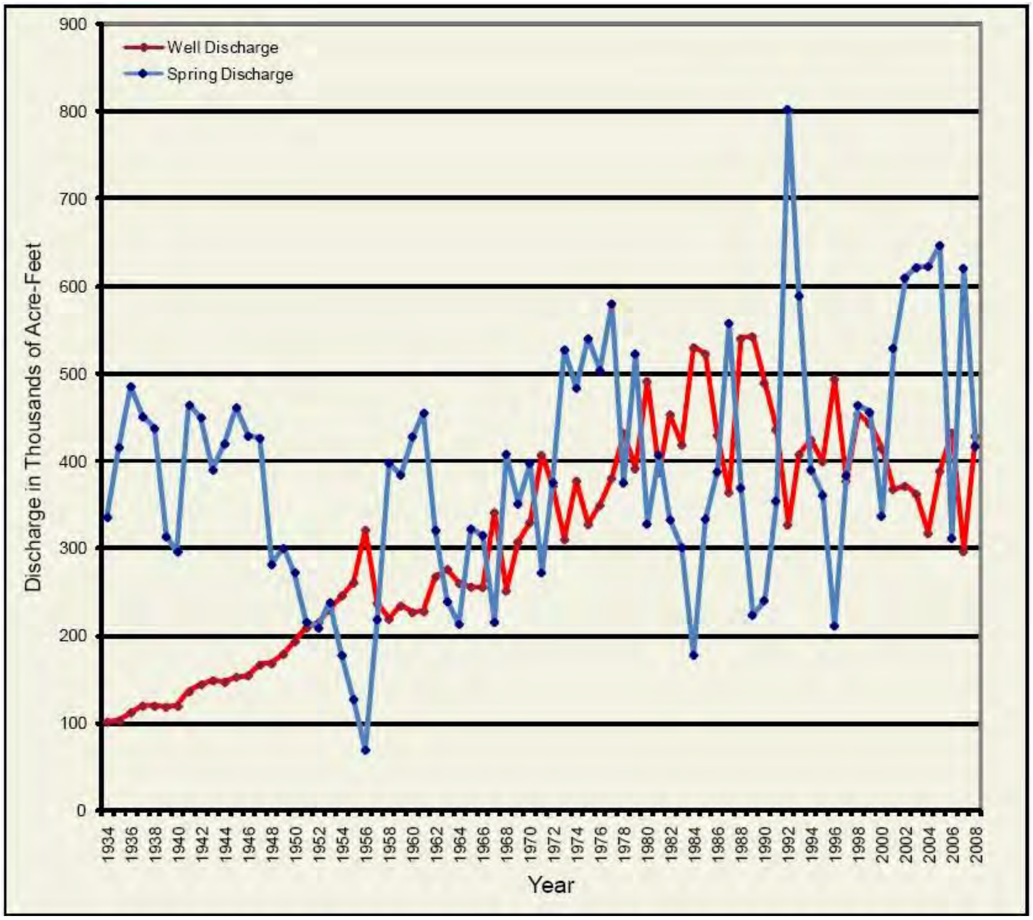
Estimated average annual recharge of the Edwards Aquifer varies according to changes in weather cycles and resulting precipitation over the Recharge Zone. Maclay (1995) reports an average annual recharge of 635,000 acre-feet. However, Klemt et al. (1979) indicates an average annual recharge of approximately 651,000 acre-feet. Data from the EAA's *2008 Hydrologic Data Report* (EAA 2009b) indicate an average annual recharge of 724,300 acre-feet for the period of record 1934-2008, and an even higher annual average of 991,700 acre-feet during the last ten-year period from 1999-2008. Lowest annual recharge (44,000 acre-feet) occurred during 1956 at the peak of the drought of record. Highest recharge (2,486,000 acre-feet) occurred in 1992.

Recharge of the Edwards Aquifer occurs by rapid infiltration of runoff from the channels of streams that flow across the aquifer Recharge Zone (channel loss) and by direct precipitation and localized runoff into recharge features such as topographic depressions, caves and sinkholes on the land surface of the Recharge Zone. Recent modeling studies evaluating the nine stream basins that traverse the Edwards Recharge Zone have ascertained that the proportion of total basin recharge occurring via stream channel infiltration or channel loss ranges from 24 percent to 93 percent (LBG-Guyton Associates 2005). Rates of infiltration of water carried by the streams across the Recharge Zone have been estimated by the U.S. Army Corps of Engineers (1965) to range from 500 to greater than 1,000 cubic feet per second (cfs). The recent analysis done for the EAA concluded that on average over the entire nine-basin area, 50 percent of the recharge occurs on land surfaces and 50 percent occurs as channel loss (LBG-Guyton Associates 2005; EAA 2009b). Previous EAA-supported efforts to refine an Edwards Aquifer model relied on an assumption that 85 percent of aquifer recharge occurred in stream channels, based on a water balance approach using records from USGS stream gages measuring streamflow upstream and downstream of the Recharge Zone (Todd Engineers 2004).

Edwards Aquifer Discharges

Water is discharged from the Edwards Aquifer through well withdrawals and from natural springs and seeps occurring near geological faults along the Edwards formation and Balcones Escarpment. Wells are the principal source of water for agricultural, municipal, and industrial uses in the region. A smaller, unknown quantity of Edwards Aquifer water is transmitted underground to the saline water zone (Maclay 1995). Water levels in the aquifer and spring discharge are greatly affected by water demand and rate of pumping. If recharge is high, the aquifer can sustain higher levels of pumping while maintaining higher levels of springflows; however, if low seasonal recharge associated with reduced rainfall is followed by high rates of pumping, then aquifer levels decrease with resulting decreased spring discharge. The historical comparison between pumping and spring discharge during the period 1934 to 2008 (EAA 2009) is shown in **Figure 5-11**.

Figure 5-11: Groundwater pumping compared with springflow from the Edwards Aquifer, 1934-2008 (measured in thousands of acre-feet)



Source: Hydrologic Data Report for 2008 (EAA 2009)

Average annual withdrawal from wells over the period of record 1934-2008 was 310,300 acre-feet (44.6 percent), in comparison to 385,000 acre-feet (55.4 percent) from springflow discharges. During droughts, the proportion of well discharge to spring discharge changes considerably. The historical comparison shown in **Figure 5-11** indicates that well withdrawals tend to spike during severe drought years while spring discharge plummets. This spring-to-well discharge relationship during droughts is probably associated with two factors: (1) there is increased demand for well water for human and agricultural uses during severe droughts, when surface water sources are diminished and (2) during severe droughts, when the ground water table is lowered as a result of reduced recharge, the additional well pumping may cause further lowering of the water table and thus contribute to reduced springflow. While droughts and associated springflow fluctuations are natural phenomena, the effects can be exacerbated by well pumping. During 1956 at the height of the drought of record, when the total annual discharge from the aquifer was approximately 392,000 acre-feet, wells accounted for 82 percent of the discharge in comparison to 18 percent for springs. During the 1984 drought there was a total discharge of 711,000 acre-feet, with well withdrawal accounting for 74 percent and spring discharge accounting for 26 percent. Similarly, during the 1996 drought well withdrawal accounted for 70 percent and springs 30 percent of the total annual discharge of 707,000 acre-feet.

During the drought year of 2008, wells contributed 51 percent of the total discharge, while spring discharge comprised 49 percent (EAA 2009b). When well withdrawals are classified by type of use, total aquifer discharge for 2008 was distributed as follows: 49 percent spring discharges, 32 percent municipal use, 13 percent irrigation use, four percent industrial/commercial use, and two percent domestic/livestock use (EAA 2009b).

Well discharge has generally increased over the period of record, and pumping peaked in 1989 at an estimated level of 542,000 acre-feet. From 1968 through 2008, annual withdrawals from wells have consistently exceeded 300,000 acre-feet, and the total discharge from the aquifer (wells plus springs) has exceeded the estimated average annual recharge (Maclay 1995). Since 1980, as a result of increased pumping, there has been greater fluctuation of springflow with increased time required for recovery, even during a period that recorded the two highest levels of aquifer recharge (1992 and 1987).

Because pumping can greatly affect the discharge of two of the aquifer's largest springs, Comal Springs and San Marcos Springs, and adversely affect their respective ecosystems, the EAA established mandatory staged pumping reductions during critical drought periods to protect aquifer levels and associated springflow discharge. The triggers for each of the critical period reduction stages are based on aquifer levels and volume of springflow discharge. During the most severe drought conditions, required reductions can be as high as 40 percent and are intended to protect the spring ecosystems that support seven endangered species: the Texas blind salamander (*Eurycea rathbuni*), fountain darter (*Etheostoma fonticola*), San Marcos gambusia (*Gambusia georgei*), Texas wild-rice (*Zizania texana*), Comal Springs riffle beetle (*Heterelmis comalensis*), Comal Springs dryopid beetle (*Stygoparnus comalensis*), Peck's cave amphipod (*Stygobromus pecki*); and one threatened species, the San Marcos salamander (*Eurycea nana*).

Recent studies conducted by the Edwards Aquifer Recovery Implementation Program (EARIP 2009) indicate that in order to sustain the spring ecosystems during extreme droughts, regional pumping would need to be curtailed by 85 percent to assure required minimum flows (long-term average flow, six-month average flow, and one-month average flow) at Comal and San Marcos Springs.

The Trinity Aquifer has historically been a source of groundwater for agricultural and residential use. Development over the aquifer has resulted in declining well production in many locations and resulting water shortages during drought conditions.

Status/Viability

The health of both the Edwards and Trinity Aquifers and associated spring ecosystems is dependent on the quantity and quality of groundwater recharge and level of aquifer discharge from pumping. Each factor is critically important to the state of the resource.

In order to maintain a healthy, sustainable aquifer, discharge to springs, wells, and other aquifers must not exceed recharge. When discharge exceeds recharge, water levels drop in the aquifer, impacting spring and well flows as well as habitat for aquifer and spring-dependent species. Recharge is controlled by the amount of precipitation available in any given year, which is widely variable in Central Texas. Multi-year droughts are routine, as are intervening years of record-breaking high rainfall. Recharge is also controlled by the amount of water available to the Recharge Zone, which can be impacted by irrigation draws on surface waters and by impermeable cover. Recharge is also affected by the amount of evapotranspiration (ET) that occurs in given settings, although the variation in ET from different plant communities pales in comparison to the variation in discharge from pumping.

As water demand increases during dry periods, aquifer discharge (i.e. pumping) increases while recharge does not. During drought, demand increases even more sharply and stresses aquifer resources. As discharge exceeds recharge, aquifer levels decline. This leads to decreased springflows, desiccation of springs and spring runs, and dry water wells. Decreased spring flows and water levels across the region point to a decline in groundwater resources (Ashworth 1983; Brune 1981; Davidson 2008; Mace et al 2000). In the Trinity Aquifer, simulations indicate that the area near Cibolo Creek in northern Bexar, southern Kendall and western Comal counties is very susceptible to water level declines due to the combination of drought and pumping withdrawals (Mace et al 2000). This report projects that the Trinity Aquifer in this area could be largely depleted by 2030. Additional development and pumping withdrawals will have a negative impact on water quantity in this area. The report also projects less severe but still significant water level declines in much of the rest of the Trinity Aquifer, particularly in Hays, Blanco, Travis, southeastern Kerr, and eastern Bandera counties.

Groundwater Quality of the Edwards Aquifer

Karst aquifers are by nature extremely vulnerable to contamination. Soils in karst areas tend to be thin and patchy. When eroded, they are slow to recover. Thus, the filtration of diffuse recharge afforded by soils is, at best, low and is only decreased by human activity. Recharge in karst systems commonly occurs as point recharge into specific karst features, bypassing what little filtration would otherwise be afforded by the soil zone. Furthermore, a karst flow system is formed by convergent flowpaths that combine to form efficient flow networks. Rapid transportation through integrated flow networks leads to lower residence times, minimizing the opportunity for the die-off of pathogens or the degradation of hazardous chemicals. These efficient flow networks can cover large areas, allowing contaminants to travel long distances very quickly, endangering distant water supplies before problems are identified (Ford and Williams 2007). Finally, monitoring of contaminant plumes is very difficult due to the nature of karst flow systems, where traditional placement of up- and down-gradient monitoring wells are likely to miss the conduits through which the contaminants are flowing (Benson and La Fountain 1984).

Historically, water from the Edwards Aquifer has been of high quality and typically fresh but hard, with an average dissolved solid concentration of less than 500 mg/l (Texas Water Commission 1992). Recent testing has revealed changes in certain water quality indicators at several locations throughout the aquifer region that may be indicative of changing conditions in water quality. Cooperative efforts between the EAA, USGS, and the TWDB have supported a systematic program of water data collection. Each year the Authority monitors the quality of water in the aquifer by sampling approximately 80 wells, eight surface water sites, and major spring groups across the region. Sample collection sites are typically selected to provide representative samples of the Recharge Zone, shallow and deep artesian zone, springs, and surface streams that flow across the recharge zone as well as areas with historical detection of anthropogenic compounds. Tests for the wells include measurements of temperature, pH, conductivity, alkalinity, major ions, minor elements (including heavy metals), total dissolved solids, nutrients, pesticides, herbicides, volatile organic compounds (VOCs), and other analytes. Results of the EAA water quality testing program during 2008 (EAA 2009b) are summarized below.

Metals

Of 81 wells sampled for metals, laboratory analyses did not indicate the presence of any metals regulated under the primary drinking-water standards at concentrations exceeding their respective maximum contaminate limits (MCLs). The metal strontium regulated under the Texas Risk Reduction Program, through, was detected above the protective concentration level (PCL) limit of 15,000 μg/L in six saline wells and one well in close proximity to the saline zone. In addition, the metals iron and manganese were detected above their secondary drinking water standards of 300 μg/L and 50 μg/L, respectively, in a Bexar County well close to the recharge zone. Strontium detections were in wells located in or close to the saline water zone of the aquifer. Iron detections were in Medina and Bexar counties, whereas the manganese detection was located in a well in Bexar County close to the recharge zone.

Bacteria

A total of 66 wells were sampled for the presence of fecal streptococcus and fecal coliform bacteria presence as colony forming units (CFU) per 100 milliliters of water (CFU/100 mL). Most well bacterial results were less than two CFU/100 mL in concentration; however, the fecal coliform bacteria results from two of the 66 wells sampled in 2008 registered three and five CFU/100 mL. In addition, fecal streptococcus bacteria were detected in three wells at two, three, and six CFU/100 mL for fecal streptococcus. Fecal coliform and fecal streptococcus bacteria are used to indicate the possible presence of fecal matter in ground and surface water. There is no public water supply MCL for fecal streptococcus.

Nitrates

Of 81 wells sampled for nitrate, none exceeded the MCL of 10 mg/L. Two wells indicated a concentration above 5 mg/L but less than 10 mg/L. Another 18 wells contained concentrations at or above 2 mg/L, including two wells in Uvalde County, three wells in Medina County, nine wells in Bexar County, three wells in Comal County, and one well in Hays County.

Volatile Organic Compounds (VOC)

Among water samples collected from 52 wells analyzed for VOCs, the compound tetrachloroethene (PCE) was detected at one well in Uvalde County at 5.6 μg/L. The MCL for PCE is 5 μg/L. This well is located within a historical PCE plume in Uvalde County and has tested positive for PCE in the past. No other VOCs were detected in routine well samples in 2008.

Semi-volatile Organic Compounds (SVOC)

Two wells were sampled for SVOCs. Neither well tested positive for SVOC compounds.

Pesticides, Herbicides, and Polychlorinated Biphenyls (PCBs)

Well water samples collected from 52 wells were analyzed for pesticides, herbicides, and PCBs. None tested positive for these contaminants.

In summary, well sampling did not indicate widespread contamination in the aquifer; however, elevated nitrate detections (greater than 2 mg/L) were present in 20 of the 81 wells sampled. Metals were detected above a regulatory limit in 8 of the 81 wells sampled. Detections of the metals strontium and iron are likely due to naturally occurring sources of these two metals. Strontium detections are typically highest in and close to the saline water part of the aquifer. Iron detections are occasionally high in some parts of the aquifer system. Manganese detection in one well is unusually high, and the well is scheduled for re-sampling in 2009. In Uvalde County, detection of the volatile compound PCE is located in an area of known PCE contamination associated with a historical spill.

Groundwater Quality of the Trinity Aquifer

Water quality of the Trinity is not as high as the Edwards in most intervals, although groundwater from Cow Creek Limestone is very good in many areas. According to results of research studies, the Trinity contains higher concentrations of sulfate, chloride and total dissolved solids in comparison to the Edwards and has had fewer detections of nitrate, pesticides, and volatile organics (Bush et al. 2000). Yields in the Trinity Aquifer are lower than in the Edwards Aquifer, by up to 250 times (Mace et al. 2000). Nonetheless, the Trinity Aquifer is used a water supply in some areas of northern Bexar and northwestern Comal Counties.

5.3.5 Ecological Resources – Vegetation and Wildlife

Overview of Resources

Physiography and Vegetation

The Edwards Plateau is a physiographic region approximately 93,240 square kilometers in size that contains several distinct subregions as defined by Griffith et. al. (2004). The RSA is located in the southern margin of the Plateau, often referred to as the Balcones Canyonlands (Griffith et al. 2004) or Hill Country region, which is bounded by the Balcones Fault Zone. This zone includes limestone, chalk, marl, claystone, and localized outcrops of intrusive igneous features, creating distinct regions that support a diversity of habitats (TPWD 2007a). The Balcones Canyonlands is highly dissected and contains steep canyons, narrow divides, and high-gradient drainages. It has been referred to as the most distinctive biotic region of Texas due to its abundant endemic biota; however, the Balcones Canyonlands is also biologically distinctive because of the intermixture of biotic elements that are characteristic of adjacent regions (Riskind and Diamond 1986).

Streams in the Balcones Canyonlands are typically dominated by bald cypress (*Taxodium distichum*), sycamore (*Platanus occidentalis*), and to a lesser extent black willow (*Salix nigra*). Buttonbush (*Cephalanthus occidentalis*) is a dominant shrub and Dwarf Palmetto (*Sabal minor*) occurs occasionally. Streamside communities are commonly narrow and adapted to periodic flooding.

Floodplains within the Balcones Canyonlands are also subject to periodic high intensity flooding and include Arizona walnut (*Juglans major*), box elder (*Acer negundo*), chittamwood (*Bumelia lanuginosa*), soapberry (*Sapindus saponaria*), Ashe juniper (*Juniperus asheii*), pecan (*Carya illinoensis*), eastern cottonwood (*Populus deltoides*), plateau live oak (*Quercus fusiformes*), Texas oak (*Quercus texana*), chinquapin oak (*Quercus muhlenbergii*), sugarberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), cedar elm (*Ulmus crassifolia*), bastard oak (*Quercus sinuata*), red mulberry (*Morus rubra*) and sometimes basswood (*Tilia caroliniana*). Deciduous holly (*Ilex decidua*), roughleaf dogwood (*Cornus drummondii*), elderberry (*Sambucus* sp.), Mexican plum (*Prunus mexicana*), and hoptree (*Ptelea trifoliata*) are frequent in the understory.

The steep slopes of the Balcones Canyonlands are characterized by Texas oak and Texas ash (*Fraxinus texensis*) or bigtooth maple (*Acer grandidentatum*). Other species which may occur include yaupon (*Ilex vomitoria*), American beautyberry (*Callicarpa americana*), hoptree, Mexican buckeye (*Ungnadia speciosa*), red or yellow buckeye (*Aesculus* spp.), deciduous holly, rough-leaf dogwood, Mexican persimmon (*Diospyros texana*), shin oak (*Quercus sinuata*), evergreen sumac (*Rhus virens*), skunkbush sumac (*Rhus aromatica*), elbow bush (*Forestiera pubescens*) and Texas mountain laurel (*Sophora secundiflora*).

Grasslands of the Balcones region typically include the following species: little bluestem (*Schizachyrium scoparium*), Texas wintergrass (*Nassella leucotricha*), slim tridens (*Tridens muticus*), Texas cupgrass (*Eriochloa sericea*), rough dropseed (*Sporobolus asper*), sideoats grama (*Bouteloua curtipendula*), seep muhly (*Muhlenbergia reverchonii*), curly-mesquite (*Hilaria belangeri*), three-awn (*Aristida* spp.), Texas grama (*Bouteloua rigidiseta*), red grama (*B. trifola*), hairy grama (*B. hirsuta*), hairy tridens (*Erioneuron pilosum*) and slim tridens. Grasslands are also being invaded by ashe juniper, mesquite (*Prosopis glandulosa*), live oak, shin oak, baccharis (*Baccharis spp.*), and prickly pear (*Opuntia spp.*).

Upland woodlands include post oak (*Quercus stellata*), live oak, cedar elm and Texas oak. In sandy soils, blackjack oak (*Quercus marilandica*) and Texas hickory (*Carya texana*) may occur. Principal vegetation types within this RSA have been mapped by the TPWD (McMahan et al. 1984) and are portrayed in **Figure 5-5**.

Wildlife

Edwards Plateau ecoregion wildlife resources have been heavily influenced by land-use changes over the last century. The RSA combines habitat types ranging from urban/suburban around the US 281 project corridor to more remote woodlands, savannahs and brushlands in the more rural settings to the north. The RSA is in a part of the Edwards Plateau known for its shallow soils over karstic limestone bedrock and its related cave and spring-dependent fauna. The physiography of the RSA allows for a wide diversity of wildlife species. According to county records maintained by the Texas A&M University Cooperative Wildlife Collection (2010b), 10 species of salamanders and newts, 22 species of toads and frogs, 14 species of turtles, 41 snakes, and the American alligator could occur in the RSA. In addition, over 120 species of birds have been documented to occur either occasionally, seasonally, or year-round within the region, while 37 species of mammals could occur within the area (Davis and Schmidly 2008).

High value aquatic habitat within the RSA consists primarily of two bodies of water, the Guadalupe River and Canyon Lake. The Guadalupe River and Canyon Lake are home to a variety of aquatic species such as bass, catfish, turtles, salamanders and beetles. They are also home to the official state fish of Texas, the Guadalupe bass (*Micropterus treculii)* as well as other game species including the largemouth bass (*Micropterus salmoides*). Additionally, the Guadalupe is seasonally stocked with rainbow trout (*Oncorhynchus mykiss*) by the TPWD (TPWD 2007; TPWD 2010c).

Historical Context

The Aguayo Expedition in the early 1700s described the area from Cibolo Creek to the Guadalupe River as, "…heavy mesquite; no plants without flowers in bloom…so close together that no weeds grew…" (Santos 1981). Early explorer's observations of the Edwards Plateau indicate a wide variety of vegetation types and brush densities and are obviously site specific. On its website, TPWD (2007) indicates that when the Edward Plateau region was settled by Europeans in the mid-1800s, it was maintained as a grassland savannah through the grazing habits of bison and antelope as well as by frequent natural and man-made fires. The land supported a rich diversity of forbs and grasses and cedar was restricted to overgrazed areas along rivers and streams, and in areas of shallow soils and steep canyons where fires did not occur frequently. White-tailed deer were rarely found in the grasslands. With European settlement came fences, cows, sheep, goats and the control of fire. Livestock were continuously grazed in fenced pastures which disrupted the natural movement patterns of grazing animals. Plants were not allowed to rest and recover from grazing. By 1900, continuous overgrazing and control of fire had taken its toll and the land gradually converted from what was primarily grassland to a brushland. Many of the woody brush species were readily browsed by sheep, goats, cattle, and an increasing deer herd. These animals tend to eat the more desirable or "ice cream" plants first and leave the less desirable plants for last. By the 1940s, many of the good quality plant species were highly depleted and not readily found on most ranges. The Edwards Plateau is now dominated by poor quality browse, forb, and grass plants. For example, Ashe-juniper, a typical dominant, is a highly undesirable forage plant for domestic livestock and deer. In much of the Edwards Plateau, cedar has become the dominant plant species, causing a once diverse and healthy landscape to become a "cedar break" in many areas, with very little plant diversity on the landscape (TPWD 2007).

White-tailed deer populations often exceed range carrying capacity and frequent droughts periodically have long term effects on wildlife populations and habitat resources. Low reproduction rates and survival of white-tailed deer fawns often results in downward population trends. Live oak, shin oak, Texas oak, blueberry and redberry juniper (*Juniperus ashei* and *Juniperus arizonica*, respectively), mesquite, lotebush (*Zizyphus obtusifolia*), yucca (*Yucca rupicola*), pricklypear, persimmon (*Diospyros texana*), hackberry (*Celtis* spp.), catclaw (*Schrankia nuttalli*), pricklyash (*Xanthoxylem americanum*), bumelia (*Bumelia lanuginosa*), sumac species, and many other woody species are common in most plant communities and contribute to habitat for many wildlife species as food and cover (TPWD 2007).

Within the Land RSA, this historical ecological conversion trend was observed through the 1970s; however, suburban development was the next trend to dominate the landscape. Analysis of aerial photography reveals that the area from the Guadalupe River to Loop 1604 realized a substantial change from rangeland to residential between 1973 and 2009. This development has resulted in a loss of native vegetation land cover and a corresponding increase in impervious cover, particularly between Borgfeld Drive and Loop 1604.

The trend over the past 15 years in the Land RSA has been an increase in small acreage landowners (5-50 acres) and in large lot development (1-5 acres) while large historic ranches have declined. Most of the small acreage landowners hold agricultural valuations and there are an increasing number that are switching to wildlife tax valuation (likely still a minority of the agricultural valuations). Though ownership of ranches in the area has historically passed through the same families for generations, the purchase of ranches by newcomers seeking a refuge from the city has become an emerging trend. Some counties in the area have also passed measures to limit deer hunting. The TPWD regulatory biologists (typically associated with rural game issues) are increasingly dealing with "urban" deer issues due in part to very high deer densities in specific locations. (Stephens 2010, personal interview).

Recreational uses throughout the Ecological RSA have increased as traditional ranching enterprises have changed. In addition to hunting and fishing, the area has become popular for bird watchers, paddle sport enthusiasts and photographers.

Status/Viability

Approximately 20 percent of the land within the Edwards Plateau ecological region has been converted to urban or agricultural land, with only 9.6 percent of the land under a wildlife management plan, and approximately 0.5 percent in public and nonprofit conserved land (TPWD 2005a). Projected population growth and trends toward subdivision development of large tracts of land are particularly high in the eastern portion of the RSA where intense development and fragmentation threatens the biodiversity and the unique hydrology of the region (TPWD 2005a). The Edwards Plateau is internationally recognized for the unique flora associated with Edwards Formation limestone and karst terrain, featuring abundant caves, springs, and limestone stream beds. It has the highest number of plant endemism of any ecoregion in the state and ranks third in number of rare plants. Of the 29 plant communities found here, three occur nowhere else in Texas and two are found nowhere else in the world (TPWD 2005a). By 1980, approximately 63 percent of bottomland hardwoods and other riparian vegetation had been lost statewide through clearing and land use conversion from anthropogenic influences (Frye 1986). These land use changes have resulted in modifications in the quality of wildlife habitats, thus affecting the distribution and abundance of wildlife species. Woodlands in the area have been somewhat adversely affected by oak wilt (*Ceratocystis facacearum*) and more recently by Hypoxylon canker, related to the droughts and prolonged heat during 2008 and 2009 in particular. These diseases have caused tree die-offs both in urban and rural areas in the Ecological RSA (Texas Forest Service 2010).

The TPWD *Comprehensive Wildlife Conservation Strategy 2005-2010* lists the following problems affecting the Edwards Plateau (TPWD 2005b):

- Human Population Density: causing increased impervious cover, heat island effect, channelization of watercourses causing erosion, lack of aquifer recharge and surface water quality issues of increased turbidity, lower dissolved oxygen, increased water temperature and chemical pollution
- Invasive Exotic Species: fragmented and disturbed land spreading exotics (such as ligustrum, bermudagrass, chinaberry, Johnsongrass, King Ranch bluestem, elephant ear, giant reed, and wild mustard) into even traditionally rural areas
- Feral Cats: causing intense non-native predation pressure to native wildlife near human population centers
- Generalist Predators: increased numbers of raccoons, blue jays, and coyotes can be harmful
- White-tailed Deer: over abundance of these animals places pressure on food resources (results in smaller, less healthy deer), increased vehicle/deer collisions, Lyme disease and impacts to urban landscape vegetation
- Habitat Fragmentation: native wildlife is at risk due to impacts to wildlife corridors, impacting access to food, water and shelter. Some important positives include land acquisitions by the City of San Antonio and others for water quality and quantity enhancement
- Reduced Diversity and Use of Non-natives in Landscaping: impacts overall diversity of wildlife (especially birds)

- Impacts to Rivers and Springs: increased population demanding increased pumping of aquifer water and both use of and impact to surface water resources

In summary, wildlife resources, including freshwater aquatic species within the RSA, have been affected by continuing land use changes and associated habitat alterations. Such alterations have resulted in the conversion of established native plant associations involving mature mixed woodland-grassland communities to urban and suburban landscapes. Wildlife habitat of higher quality (native prairies, mature or old growth woodlands) is declining in favor of more fragmented, younger, less diverse vegetation communities in both uplands and in riparian corridors. Such alterations have affected wildlife species composition, distribution, and abundance and have contributed to the growth of wildlife species that are adaptable to human disturbance and proximity (with a corresponding decline in those species that occur in larger, undisturbed tracts). Aquatic habitats have also been altered with continuing risk to hydrological and ecological integrity. Therefore, while vegetation and wildlife resources are considered stable, future decline in more diverse, higher quality habitats is expected as a result of future development.

5.3.6 Ecological Resources –Threatened and Endangered Species

Historical Context

Historical Context – Mussels

Roughly 29 species of mussels have been known to occur in the Ecological RSA and, on a statewide basis, only half of the currently extant species are considered secure (Howell 2010). The major threats to freshwater mussels are related to life cycle interruptions, loss of habitat, exotic species, climatic and weather shifts as well as land use patterns (reservoir construction, channelization, overgrazing by livestock) which have changed flow regimes and negatively impacted water quality due to increased salinity, erosion and siltation (Howell 2010). In addition to the existing threats, additional pressure from exotic species is thought to be on the horizon (Howell 2010).

Springtails (*Pseudosinella violenta*) in association with cave cricket guano and fungi on in a Bexar County cave, representing aspects of the base of the food chain.

Photo by Dr. Jean Krejca.

Historical Context – Terrestrial Karst Species

The direct impact area and almost all of the resource study area is a karst landscape. In this zone, limestone bedrock is dissolved by mildly acidic rain and groundwater to create caves and sinkholes. Many cave passages do not currently have humanly-enterable entrances, and are discovered accidentally during construction activities. Other caves, initially detected as karst features, are opened up in the course of endangered karst species assessments. Karst invertebrate species are not limited to humanly-enterable caves; they also exist in innumerable small voids within karstic limestone that are known as mesocaverns (Sprouse and Krejca 2009). The karst species habitat within caves and mesocaverns does not exist in isolation from the surface. Rather, it is a very porous zone that is dependent on surface nutrient and moisture input. Water enters the subsurface not only at obvious cave entrances and seemingly plugged sinkholes, but also generally across the karst landscape. This general recharge occurs at the soil/bedrock interface via the semi-dissolved upper layer of limestone known as epikarst.

These epikarstic portals lead into the mesocavernous zone and also introduce nutrients such as organic debris, roots, and micro-fauna. Cave entrances allow surface species such as bats, porcupines, and cave crickets to enter the subsurface and thereby introduce energy in the form of scat and corpses. Organic debris such as leaf litter is also washed into cave entrances by flood waters. The input of organic debris and moisture are crucial to subterranean ecosystems.

Natural surface vegetation communities are important to karst ecosystems in a number of ways. Animals which shelter in caves but forage on the surface, known as trogloxenes, are one of the most significant sources of cave energy input. Cave crickets, primarily *Ceuthophilus secretus,* often populate caves in large numbers during the day, then travel to the surface at night to feed. This species has been documented to forage as far as 105 meters from the cave entrance, and may travel even farther (Taylor 2005). Stable isotope studies of cave cricket gut contents have shown that native vegetation is a major component of their diet (Taylor et al. 2007). When cave crickets return to the cave to roost, they leave significant quantities of guano, which provides a major food source for lower invertebrates such as springtails. Taylor et al. (2007) have shown that a reduction in the area of natural vegetation around a cave entrance results in lower cave cricket populations, with a corresponding drop in overall numbers of troglobites. Clearing land of natural surface vegetation communities can also result in increased occurrence of the invasive Red Imported Fire Ant (RIFA) *Solenopsis invicta*. This species threatens the karst ecosystem by competing for food with cave crickets and also by entering caves and predating directly on karst species. The presence of dense surface vegetation also promotes the important infiltration of water to the subsurface by slowing down runoff and by maintaining thick soil and humus. Use of caves by vertebrate species such as porcupines may depend in a similar way upon the existence of natural vegetation on the surface, and play a similar role in the introduction of important nutrients to subterranean ecosystems.

Historical Context – Aquifer Species

Seven federally endangered and one threatened species are dependent on the San Marcos and Comal Springs ecosystems. These include two salamanders, the Texas blind salamander and San Marcos salamander; two fishes, the fountain darter and San Marcos gambusia; two aquatic insects, the Comal Springs riffle beetle and Comal Springs dryopid beetle; one crustacean, Peck's Cave amphipod; and one plant, Texas wild-rice.

Historical data regarding population trends for these species is largely unavailable and discussions regarding the species viability, whether historical or current, tend to focus upon flow regimes at the springs. Despite the fact that Comal Springs is thought to have the greatest discharge of any springs in the Southwest, its flows diminish during drought conditions. These springs completely ceased to flow for months during the drought of record in the summer and fall of 1956. Despite that impact scenario, Comal Springs remains home to several rare, listed species. The San Marcos Springs complex is the second largest spring complex in Texas. It has historically exhibited the greatest flow dependability and environmental stability of any spring complex in the Southwest (USFWS 1996). The springs have never ceased flowing, even during the drought of record.

Historical Context – Cagle's Map Turtle

On April 8, 1991, the Cagle's map turtle was petitioned to be listed as a federally endangered species (Killebrew 1991) and was designated as a candidate species on January 22, 1993. The USFWS indicated that listing of the species was warranted, but precluded at that time because the agency lacked the resources to propose the species for listing (58 FR 5701). Several years later, the TPWD listed Cagle's map turtle as a State-threatened species on November 16, 2000 (Texas Register, Title 31, Chapter 65). After reviewing the turtle's status, the USFWS announced on September 12, 2006 that, because of stable population size, increased protection, and no foreseeable threats from reservoir construction, the listing of Cagle's map turtle was no longer warranted (71 FR 53767).

The Cagle's map turtle formerly ranged throughout the watersheds of the Guadalupe and San Antonio Rivers (Dixon 1987, Conant and Collins 1991), but may now be extirpated in the San Antonio River basin (Vermersch 1992). This turtle tends to inhabit limestone or mud-bottomed streams with moderate current and pools of varying depths. It may also be found in slow-moving water behind impoundments (Vermersch 1992).

Historical Context – Texas Horned Lizard

The Texas horned lizard (THL), one of three horned lizard species in Texas, was historically distributed across much of the state, with the exception of far East Texas. Recent studies and anecdotal accounts indicate the THL has declined in much of its range. These declining numbers, perhaps caused in part by over-collection, led TPWD to list the species as threatened in 1977. The THL's current distribution, causes of decline, and current population trends are under study and relatively uncertain (Linam 2008).

Historical Context – Golden-cheeked Warbler

Historically, habitat loss and fragmentation were the major reasons for the decline in the GCWA population. Pulich (1976) reported that the species had been recorded in 41 Texas counties but was known from only 31 counties in 1976; however, Morrison et al., (2010) indicate the current breeding range comprises 34 Texas counties. A juniper eradication program was implemented in Texas in 1948 aimed at improving pasture conditions. From the 1950s to the 1970s, about 50 percent of the juniper acreage was cleared for pasture improvement and urbanization (USFWS 1990), as well as for use for fence posts, furniture, and cedar oil (USFWS 1992). Several counties that had been GCWA habitat, including portions of Gillespie County and all of Mason County, no longer contained suitable habitat by the 1970s (USFWS 1990). The current threat to the Ashe juniper-oak woodland is urban sprawl, growth of urban areas with known GCWA populations (such as the City of Austin), and the conversion of wooded areas to agricultural land. In 1992, 60 percent of the remaining warbler habitat was located in the fastest urbanizing counties of Texas (including Travis, Bexar, and Kerr) (Sexton 1992). Because of the growth and development in this corridor, the greatest rate of GCWA habitat loss has occurred in the southern and eastern portions of the Edwards Plateau (USFWS 1990). Since no systematic range-wide population census is taken of this species, it is unknown whether rebound has occurred. Most authors point to recent, rapid habitat losses as an indication that the opposite is true. According to the GCWA recovery plan, other major threats to the species include the creation of impoundments for flood control and livestock, loss of winter and migration habitat, destruction of oaks by oak wilt, over-browsing by livestock and white-tailed deer, nest parasitism, and habitat fragmentation (USFWS 1992). The best habitat for this species is and has long been considered to be along the Balcones Escarpment, specifically in Travis County. Presently, recent habitat losses indicate that the health trend of the species is not good.

Historical Context – Black-capped Vireo

At the time they were listed in 1987, black-capped vireos were known to have a breeding range across four counties in Oklahoma, 21 counties in Texas, and in Coahuila, Mexico. The historic breeding distribution however was thought to include a much larger area extending from Kansas southward through central Oklahoma and through west-central Texas, with a southern limit in central Coahuila, Mexico.

The major threats at the time of listing included brood parasitism by brown-headed cowbirds, habitat loss and fragmentation through land use conversion, overgrazing by domestic livestock and wild herbivores, vegetation succession through cessation of fire, oak wilt, pesticides, low reproductive success, and low recruitment (survivability) (USFWS 1991; Wilkins et al. 2006).

Habitat conversion through land use changes may be one of the greatest threats to the species (Wilkins et al. 2006). The authors describe breeding habitat for the BCVI as an area that is usually in the early-transitional stages following some form of disturbance. They also comment that through vegetation succession, vireo habitat will usually be converted either from prairie grasslands to closed-canopy hardwood forest or cedar brakes so dense that the necessary understory is suppressed (Wilkins et al. 2006). Historically, BCVI habitats would be maintained through natural fires every three to five years, removing Ashe juniper and other dense, overgrown areas and promoting the growth of more fire-resistant woody species and scrubland vegetation used by BCVI. Suppression of natural fire may have caused some BCVI habitat to become overgrown by an increase of woody cover unsuitable for use. In the eastern portion of the BCVI range, active management is required to maintain BCVI habitat by suppressing increases of woodlands (TPWD 2004).

Status/Viability (Health of the Resource)

Current Health – Mussels

Health of the Texas-listed species is declining according to Howell (2010). Fifteen species have been recently (December 2009) listed by TPWD as threatened and eight are under consideration for federal listing by the USFWS. As stated in the previous section, detailed distribution and population data are not available for this suite of species. Generally, the status of surface water quality in the Guadalupe River basin, including perennial streams and rivers, will dictate the fate of these species in the Ecological RSA. Brief status reports for the four species in the Ecological RSA are offered from Howell (2010) below:

- False spike – not seen alive in Central Texas since 1970s; dead individuals found in San Marcos in 2000 but none found in recent surveys;
- Golden orb – populations present in lower and central San Marcos and Guadalupe basins; small population in Guadalupe River near Kerrville recently lost;
- Texas fatmucket – only observed alive since 2004 at one stream in Runnels County, one site in Menard County, two sites in Gillespie County and one site in

Kerr County; all outside the Ecological RSA; Runnels, Menard and Kerr sites tenuous;

- Texas pimpleback – only observed since 2004 at two locations outside the Ecological RSA (Concho River and Guadalupe River near Victoria)

Current Health – Terrestrial Karst Species

The following text comes from the Draft Preliminary Assessment for Nine Federally-Listed Bexar County Karst Invertebrates (Zara 2010).

The known distributions of the nine federally listed Bexar County karst invertebrates throughout the six delineated KFRs are summarized in **Table 5-4.**

Table 5-4: Distribution of Federally-listed Bexar County Karst Invertebrates in KFRs and Number of Localities for Each (Veni 2003)

Species	KFR	Number of known localities
Rhadine exilis	Government Canyon	52
	UTSA	
	Helotes	
	Stone Oak	
Rhadine infernalis (including subspecies)	Government Canyon	36
	UTSA	
	Helotes	
	Stone Oak	
	Culebra Anticline	
Batrisodes venyivi	Government Canyon	8
	Helotes	
Texella cokendolpheri	Alamo Heights	1
Neoleptoneta microps	Government Canyon	2
Cicurina baronia	Alamo Heights	2

Source: Zara 2010

Regulatory Status

The nine Bexar County karst invertebrates were federally-listed as endangered species on December 26, 2000 (65 FR 81419). All species have a recovery priority of 2c, which "indicates that these species face a high degree of threat with a high potential for recovery and there may be conflict between species recovery and economic development" (USFWS 2011). Critical habitat was designated on April 8, 2003 for all of the species, except the Government Canyon Bat Cave spider (*Neoleptoneta microps*) and Government Canyon Bat Cave meshweaver (*Cicurina vespera*). None of these species or their habitats receives direct protection under Texas state law, since invertebrates are not included on TPWD's list of threatened and endangered species.

Karst Zones in Bexar County

The northern portion of Bexar County is located on the Edwards Plateau, a broad and flat expanse of Cretaceous carbonate rock that ranges in elevation from approximately 1,100 feet to 1,900 feet above mean sea level. The principal, cave-containing rock units of the Edwards Plateau are the upper Glen Rose, Edwards Limestone, Austin Chalk, and Pecan Gap Chalk formations. One-third of the cavernous rock exposed at the surface in Bexar County is of the Edwards Limestone formation, making it the most cavernous unit in the country (Veni 1988; Veni 1994). Based on the geologic restrictions on the distribution of cave fauna and the locations of known caves, Veni (1994) delineated five karst zones that reflect the relative likelihood of finding any of the Bexar County listed troglobites (and other rare or endemic karst species). These five zones are defined in **Section 5.2.4** , above).

Under contract with the USFWS, Veni (2002) re-evaluated and, where applicable, redrew the boundaries of each karst zone originally delineated in Veni (1994). Revisions were based on current geologic mapping, further studies of cave and karst development, and the most current information available on the distribution of listed and non-listed troglobites (Veni 2002).

Additionally, Veni (1994) established six geographic areas called Karst Fauna Regions (KFRs) within the Bexar County Karst Zones. These divisions were defined by hydrogeologic barriers and/or other restrictions to the migration of troglobitic species over evolutionary time (Veni 2009). These six KFRs were used in the USFWS final rule designating critical habitat to define the ranges of the listed species and are as follows (**Figure 5-6** in **Section 5.2.4** illustrates the boundaries of these KFRs):

1. Stone Oak
2. UTSA
3. Helotes
4. Government Canyon
5. Culebra Anticline
6. Alamo Heights

Karst habitats in Central Texas have been affected primarily by human alteration to natural systems generally related to land clearing and impervious cover increases. Alteration of natural habitat over the karst can affect moisture input to the karst ecosystem in a number of ways. Clearing of land by removing vegetation with machinery has multiple effects. It will typically increase sedimentation as soil is exposed, which can result in the plugging of karst features, reducing their ability to absorb water, while also introducing material to the subsurface that may be detrimental to cave ecosystems.

Reduction of surface vegetation can also decrease absorption of water into the soil and subsequently the limestone bedrock, since runoff speed increases and increased sunlight speeds evaporation. Channelizing water flow into drainage ditches can reduce recharge by diverting sheet flow that originally entered karst features. The creation of impervious cover such as roads, parking lots, and buildings eliminates recharge in those areas, and has the effect of drying out cave passages and mesocavernous voids that lie under them. These features would also be robbed of nutrient input that would have been introduced by water flow and tree roots. Water that does enter the subsurface after flowing across impervious cover and through drainage ditches would inevitably pick up contaminants from automobiles, industrial, and retail sources. While there are pollution abatement impoundments at some facilities in the area, little information is available as to how effective these efforts are at preventing contamination of the subsurface. In 2007, efforts to control a mulch fire in Helotes, Texas over the Edwards Aquifer Recharge Zone resulted in ash contamination of local wells (SAWS 2010). Contaminated surface water in the recharge zone must pass through caves and mesocavernous habitat to reach the aquifer. Additional sources of potential contamination of karst habitat include septic systems and leaks from sewage pipelines, liquid fuel pipelines and storage tanks.

In addition to karst invertebrate species habitat declines, vertebrate species dependent upon karst environments have also been negatively affected by human related impacts. Bat species nationwide have been severely impacted by a disease known as white-nose syndrome (WNS). Though the exact nature of the disease is unclear, it has caused devastating losses to bat populations (some as high as 90 percent) in the eastern US and has spread quickly, as far west as Oklahoma. Due to the prevalence and severity of the risk associated with this disease, all cave-dwelling bat species should be considered at risk.

Current Health – Aquifer and Spring-Associated Species

Rapid urbanization and agricultural development occurring around springs and over the Edwards Aquifer threatens to degrade aquifer habitat through direct habitat loss (from destruction or from reduced springflows) and increased siltation of the aquifer and springs (Bendik 2006). Contamination to groundwater has a negative impact on both spring dwelling and cave dwelling species. Habitat loss occurs both when springs are destroyed mechanically and when they cease to flow due to aquifer drawdown. Habitat loss in caves occurs when the cave is filled in or becomes heavily silted, and when the water table drops low enough to cause caves with typically perennial water to become dry.

Threats to the continued persistence of these species include human disturbances and rapid development resulting in aquifer drawdown and decreased spring flow, and competition with or predation by non-native species. Many of these species are geographically restricted, making them especially vulnerable to disturbance, which could lead to a decrease in population size. Smaller populations are more susceptible to problems associated with reduced genetic variability and heterozygosity.

The health of karst aquifers can be measured in two ways: water quantity and quality. The quantity of water in an aquifer is a result of the affects of recharge and discharge. Recharge occurs when surface water in the recharge zone enters the bedrock subsurface via caves and karst features, enhanced in some cases by recharge structures. Aquifer discharge occurs via springs and withdrawals from wells. Water may also be lost to the saline water zone in the deep portions of the eastern Edwards Aquifer.. Discharge is greatly affected by the demands of increasing development and urbanization that result in high rates of withdrawal from wells. If recharge is high, the aquifer can sustain higher levels of pumping and adequate levels of flow for aquifer and spring-associated species. During dry periods reduced recharge combined with increased demand causes aquifer levels to decline and spring flow to decrease.

Water quality in the Edwards Aquifer is monitored at wells and springs by several entities, including the EAA, US Geological Survey (USGS), and the TWDB. Water in the Edwards Aquifer is generally considered high quality. However, elevated levels of nitrates and metals have been detected. Treated wastewater from both municipal treatment plants and septic systems can and does reach the Edwards. Aquifer emerging contaminants such as pharmaceuticals cannot be removed by wastewater treatment. The long term effects of these anthropogenic compounds on aquifer species are unknown. The endangered Barton Springs Salamander (*Eurycea sosorum*) is known to suffer from a condition called gas bubble trauma (USFWS 2005). Gases such as nitrogen from supersaturated water forms bubbles inside the body, leading to death. Anthropogenic factors that can lead to supersaturation include warm water discharges, algal blooms, and air injection into water by dam flow and pump pressurization. While

Barton Springs lies outside the RSA, it is quite similar to Comal and San Marcos Springs, and there is no reason to believe that gas bubble trauma could not occur in *Eurycea* species at those or other sites.

Knowledge of the health of aquifer and spring species is limited with no standard population references. The health of this suite of species goes hand in hand with the quantity and quality of the Edwards Aquifer and, in particular, the output of the Comal and San Marcos springs. At the moment, flow is sufficient; however, development in the area continues, and urban and agricultural demands on water resources continue to grow. Studies are being conducted on Edwards Aquifer species that may shed light on trophic level dynamics. One method in use is stable isotope analysis, which enables biologists to identify the lower species an organism is feeding on. This information helps identify the trophic hierarchy and which species at the base may be subject to contamination that may affect species at higher trophic levels.

Aquifer-dependent species are particularly vulnerable to aquifer and spring outlet threats given their geographically narrow habitat niches. The most obvious threat to the aquifer-dependent listed species is the intermittent loss of habitat from reduced springflows. Springflow losses result from a combination of naturally fluctuating rainfall patterns, regional pumping, and related intermittent aquifer drawdown. Other threats include invasive non-native species, recreational activities, predation, and direct or indirect habitat destruction or modification by humans and other factors that decrease water quality (USFWS 1996).

Current Health – Cagle's Map Turtle

Cagle's map turtle is currently found only in segments of the Guadalupe and San Marcos Rivers in Kerr, Kendall, Comal, Guadalupe, Gonzales, DeWitt, Hays, and Victoria Counties (Dixon 1987; Killebrew 1992; Killebrew and Porter 1991; Porter 1992).

Surveys using time-constrained basking turtle frequency indices and mark-recapture studies indicate that the total estimated population of *Graptemys caglei* in the Guadalupe river is 11,717 (Babitzke 1992). The majority of the population is thought to occur in the section of the river between New Braunfels and Victoria (Killebrew et al. 2002).

Current Health – Golden-cheeked Warbler

The most serious problems facing the golden-cheeked warbler today, as in the recent past, are habitat loss and fragmentation. Since warblers have limited and specific habitat requirements, direct habitat loss has resulted in population reduction, although precise comparisons of historic and current populations are not available.

Recently, serious losses in nesting habitat have occurred in counties such as Travis, Williamson, and Bexar, where rapid urban development has spread into oak-juniper woodlands associated with canyonlands. Flood control and other impoundments have also reduced habitat for the warbler by inundating the juniper-oak woodlands existing on canyon slopes and bottoms along springs, streams, and rivers. Construction of large reservoirs has also led to loss of warbler habitat due to development of lake-side communities (USFWS 1996a).

Current Health – Black-capped Vireo

Four well-surveyed areas, Fort Hood (Texas), Kerr WMA (Texas), Wichita Mountains WR (Oklahoma), and Fort Sill (Oklahoma), comprise about 75 percent of the known black-capped vireo population in their breeding range. The remaining 25 percent are found on 52 recently-surveyed properties, consisting mostly of private lands. (Wilkins et al. 2006). At the time of listing (1987), there were only 280 male BCVI from 21 counties in Texas. However, from 1996 to 2005, there were 3,515 males documented from 38 Texas counties. Much of this growth is likely due to an increase in survey efforts. Additionally, that effort has not been evenly applied across the species' potential breeding range. Because of this, it has been difficult for researchers to accurately identify population trends. Despite inconsistent and unequal survey efforts, there are a few things to consider: the total number of known males in breeding surveys has largely increased since the time of listing; most of these increases have occurred in areas that have had the most intense survey efforts such as Fort Hood and Kerr WMA; and black-capped vireos occur more often on private lands in Texas than known at the time of listing. This is partially due to increased survey efforts and it remains uncertain if these populations have actually increased (Wilkins et al. 2006). The portion of the BCVI RSA we are concentrating on in this report falls within the BCVI Texas Recovery Region 3 (**Figure 5-8**). Based on recent surveys, there are approximately 1,018 breeding males in this region (Wilkins et al. 2006).

Habitat loss due to land use conversion appears to be the major problem facing the BCVI today, mostly due to the rate at which it is being converted. However, other problems such as vegetation change, overbrowsing by white-tailed deer and exotic ungulates, and predation by fire ants and rat snakes have also increased since the time of listing. Threats researchers believe have decreased include overbrowsing by livestock and brood parasitism by Brown-headed Cowbirds (Wilkins et al. 2006).

5.4 STEP 4: IDENTIFY DIRECT AND INDIRECT IMPACTS OF THE PROJECT THAT MIGHT CONTRIBUTE TO A CUMULATIVE IMPACT

This section represents the results of Step 4 in conducting the Cumulative Effects analysis. An evaluation of the direct and indirect effects of both proposed Build Alternatives is presented in **Chapter 3 - Affected Environment and Environmental Consequences** and **Chapter 4 - Indirect Effects**. The assessment addressed both direct and indirect effects for the following major resource categories: Land Resources, Socioeconomic and Community Resources, Air Quality, Surface Water and Groundwater Resources, Vegetation and Wildlife, Threatened and Endangered Species, and Archeological and Historic Resources. Indirect effects are further divided into effects resulting from encroachment-alteration (EAlt) and induced growth (IG). A summary of direct and indirect effects for each of the Proposed Build Alternatives is presented in **Table 5-5**.

Table 5-5: Summary of Direct and Indirect Effects

Resource Category	Proposed Build Alternatives			
	Expressway Alternative		Elevated Expressway Alternative	
	Direct	Indirect	Direct	Indirect
Land Resources				
Additional ROW Total ROW	130.03 acres 513 acres	n/a	103.43 acres 483 acres	n/a
Total Potential Displacements	28	EAlt: no probable substantial effect IG: n/a	28	EAlt: no probable substantial effect IG: n/a
Residential	1		0	
Commercial	26		28	
Utilities	1		0	
Parks/Recreational & Public Facilities	none	EAlt: no probable substantial effects IG: no probable substantial effects	none	EAlt: no probable substantial effects IG: no probable substantial effects
Potential Hazardous Materials/Known Sites	8 sites	EAlt: not determined beyond direct effects IG: undeterminable, due to uncertainties about development footprint	8 sites	EAlt: not determined beyond direct effects IG: undeterminable, due to uncertainties about development footprint
Area Subject to Induced Growth	n/a	EAlt: n/a IG: 18,574 acres	n/a	EAlt: n/a IG: 19,096 acres
Socioeconomic & Community Resources				
Total Project Cost	$433,985,133	n/a	$646,184,035	n/a
Construction Costs	$376,871,641		$581,610,061	
ROW Costs	$30,732,477		$23,861,270	
Engineering Costs	$26,381,015		$40,712,704	
Additional Cost for Toll or Managed Option	$14,000,000		$9,000,000	
Income/Employment Effects	TBD		TBD	
Community Safety and Mobility	None	EAlt: beneficial impacts on safety and improved mobility for community members; no substantial negative effects IG: no substantial effects	None	EAlt: beneficial impacts on safety and improved mobility for community members; no substantial negative effects IG: no substantial effects
Vulnerable Elements of the Population	None	EAlt: no substantial effects IG: no substantial effects	None	EAlt: no substantial effects IG: no substantial effects

Table 5-5: Summary of Direct and Indirect Effects

Resource Category	Proposed Build Alternatives			
	Expressway Alternative		Elevated Expressway Alternative	
	Direct	Indirect	Direct	Indirect
Air Quality				
Air Quality Issues, including Conformity with National Ambient Air Quality Standards, and MSAT	Direct impacts on air quality and MSATs from the project are primarily those associated with the increased capacity, accessibility and the resulting projected increases in VMT. Emission reductions as a result of EPA's new fuel and vehicle standards are anticipated to offset impacts associated with VMT increases.	Indirect impacts on air quality and MSATs are possible in relation to induced growth. Sources of increased air pollutant emissions resulting from induced development will be subject to relevant authorizations and regulatory emissions limits and control practices established by the TCEQ and the EPA, and are not expected to result in substantial degradation of air quality or MSAT.	Direct impacts on air quality and MSATs from the project are primarily those associated with the increased capacity, accessibility and the resulting projected increases in VMT. Emission reductions as a result of EPA's new fuel and vehicle standards are anticipated to offset impacts associated with VMT increases.	Indirect impacts on air quality and MSATs are possible in relation to induced growth. Sources of increased air pollutant emissions resulting from induced development will be subject to relevant authorizations and regulatory emissions limits and control practices established by the TCEQ and the EPA, and are not expected to result in substantial degradation of air quality or MSAT.
Water Resources – Surface Water				
Surface Water Quality	Temporary construction related impacts will be minimized	EAlt: probable substantial effects from highway runoff and possible effects from spills IG: probable substantial water quality effects associated with projected development on approximately 18,574 acres; more substantial effects in the Upper Guadalupe and Canyon Lake drainages	Temporary construction related impacts will be minimized	EAlt: probable substantial effects from highway runoff and possible effects from spills IG: probable substantial water quality effects associated with projected development on approximately 19,096 acres; more substantial effects in the Upper Guadalupe and Canyon Lake drainages
Increased Watershed Impermeable Surface Area	86 acres	EAlt: n/a IG: not quantified; expected to exceed 10 percent in some sub-watersheds; effects would be more substantial with the Expressway Alternative	83 acres	EAlt: n/a IG: not quantified; expected to exceed 10 percent in some sub-watersheds; effects would be slightly less substantial than the Expressway Alternative
Stream Crossings/ Length and Wetlands	12 crossings/ 7,137 feet 2 small wetland areas	EAlt: no probable substantial effects IG: undeterminable, due to uncertainties about development footprint	12 crossings/ 4,970 feet 2 small wetland areas	EAlt: no probable substantial effects IG: undeterminable, due to uncertainties about development footprint

Table 5-5: Summary of Direct and Indirect Effects

Resource Category	Proposed Build Alternatives			
	Expressway Alternative		Elevated Expressway Alternative	
	Direct	Indirect	Direct	Indirect
Groundwater Quality	Potential for impacts associated with contamination events, spills, or from non-point source contaminated runoff	EAlt: probable substantial effects from highway runoff and possible effects from spills IG: probable limited water quality impacts associated with projected development on approximately 4,442 acres in the Cibolo and Dry Comal Creek drainages	Potential for impacts associated with contamination events, spills, or from non-point source contaminated runoff	EAlt: probable substantial effects from highway runoff and possible effects from spills IG: probable limited water quality impacts associated with projected development on approximately 4,592 acres in the Cibolo and Dry Comal Creek drainages
Development in Area Upstream of Recharge Zone Contributing to Aquifer Quality	104 acres	EAlt: not quantified IG: 3,830 acres projected to develop that will alter runoff quality	93 acres	EAlt: not quantified IG: 3,910 acres projected to develop that will alter runoff quality
Area Overlying Edwards Aquifer Recharge Zone	409 acres	EAlt: not quantified IG: 610 acres projected to develop	390 acres	EAlt: not quantified IG: 687 acres projected to develop
Ecological Resources - Vegetation & Wildlife				
Vegetation/Wildlife Habitat Cleared, Disturbed, or Altered: Non-urban Vegetation Cover Types	75 acres	EAlt: not quantified; further habitat fragmentation IG: habitat fragmentation, alteration and/or loss; effects associated with projected development on approximately 18,142 acres 432 acres	65 acres	EAlt: not quantified; further habitat fragmentation IG: habitat fragmentation, alteration and/or loss; effects associated with projected development on approximately 18,654 acres 442 acres
Urban/Sparsely Vegetated Cover Type	284 acres		267 acres	
Known or Potential Karst Features Impacted	33	EAlt: possible substantial effects IG: unquantified, effects would be more substantial for the Expressway Alternative than the Elevated Expressway Alternative	29	EAlt: possible substantial effects IG: unquantified, effects would be less substantial for the Elevated Expressway Alternative than the Expressway Alternative

Table 5-5: Summary of Direct and Indirect Effects

Resource Category	Proposed Build Alternatives			
	Expressway Alternative		Elevated Expressway Alternative	
	Direct	Indirect	Direct	Indirect
Other Wildlife Effects (Wooded Potential Habitat)	64.9 acres within ROW	EAlt: no substantial effects IG: unquantified, effects would be more substantial for the Expressway Alternative than the Elevated Expressway Alternative	55.9 acres within ROW	EAlt: no substantial effects IG: unquantified, although effects would be less substantial for the Elevated Expressway Alternative than the Expressway Alternative
Golden-cheeked Warbler Potential Habitat	64.9 acres within ROW	EAlt: no probable substantial effects IG: 5,057-7,417 acres of potential habitat subject to induced growth	55.9 acres within ROW	EAlt: no probable substantial effects IG: 5,263-7,668 acres of potential habitat subject to induced growth
Golden-cheeked Warbler Occupied Habitat	none – based on two years of surveys	EAlt: none IG: undeterminable, due to uncertainties about development footprint and habitat use by GCWA	none – based on two years of surveys	EAlt: none IG: undeterminable, due to uncertainties about development footprint and habitat use by GCWA
Karst Invertebrates Potential Habitat	Zone 1: 8 features/61 acres of additional ROW Zone 2: 2 features/35.8 acres of additional ROW Zone 3: 5 features/31.5 acres of additional ROW	EAlt: no probable substantial effects IG: undeterminable, due to uncertainties about development footprint and habitat locations	Zone 1: 8 features/57 acres of additional ROW Zone 2: 1 feature/20.3 acres of additional ROW Zone 3: 5 features/21.6 acres of additional ROW	EAlt: no probable substantial effects IG: undeterminable, due to uncertainties about development footprint and habitat locations
Karst Invertebrates Occupied Habitat for Known Listed Species	None	EAlt: no probable substantial effects IG: no projected impacts – induced growth areas outside of known habitat zones	None	EAlt: no probable substantial effects IG: no projected impacts – induced growth areas outside of known habitat zones
Aquifer-associated Species	None	EAlt and IG: For Comal Springs species, groundwater flow paths from recharge areas near project ROW result in finding of “may affect not likely to adversely affect”	None	EAlt and IG: For Comal Springs species, groundwater flow paths from recharge areas near project ROW result in finding of “may affect not likely to adversely affect”
Other species of concern				
Other, State-listed Species of Concern	Not likely to negatively impact the Texas horned lizard and the timber rattlesnake	EAlt: no probable substantial effects IG: not quantified	Not likely to negatively impact the Texas horned lizard and the timber rattlesnake	EAlt: no probable substantial effects IG: not quantified

Table 5-5: Summary of Direct and Indirect Effects

Resource Category	Proposed Build Alternatives			
	Expressway Alternative		Elevated Expressway Alternative	
	Direct	Indirect	Direct	Indirect
Cultural Resources				
Archeological Resources	None	EAlt: no probable substantial effects IG: no probable substantial effects*	None	EAlt: no probable substantial effects IG: no probable substantial effects*
Historic Resources	None	EAlt: no probable substantial effects IG: no probable substantial effects**	None	EAlt: no probable substantial effects IG: no probable substantial effects**

Source: US 281 EIS Team, 2011
EAlt: Indicates indirect impacts that would result from encroachment-alteration effects
IG: Indicates indirect impacts that would result from induced growth effects
*These costs include a five percent mobilization fee as well as equipment costs and installation. Within the professional services, there are allowances for design, testing, project management, and software license fees. The equipment costs include gantries, video cameras, lighting, UPS and backup generator, equipment housing, toll related signage, MOMS, communication systems, AVC system, a pavement tolling apron (including markings, lane controls etc) and the foundations and geotechnical design of the gantries. The Expressway Alternative cost is based on four assumed tolling locations and the Elevated Expressway Alternative cost is based on three assumed tolling locations.
*Effects to cultural resources (historic and archeological) are discussed in further detail in Step 6 due to the likelihood of undocumented cultural resources within areas subject to induced development

5.5 STEP 5: IDENTIFY OTHER REASONABLY FORESEEABLE FUTURE EFFECTS

This section represents Step 5 in conducting the cumulative effects analysis, the identification of other current and reasonably foreseeable future actions to be considered in the cumulative impact analysis. The focus is on actions or developments that are independent of the proposed action. “Reasonably foreseeable” means actions that are expected to occur within the 2035 timeframe established in Step 2 and are likely or probable, rather than merely possible. This information is based on input from the collaborative judgment Land Use Panel (described in **Section 4.6.2**), a residential absorption analysis performed by SA Research Corporation (described in **Section 5.5.2** and **Appendix M**), interviews with local officials (including those listed in **Table 4-11**), and a review of projects, resources, policies, developments, land use plans and maps prepared by federal, state, and local government agencies (see **Section 4.2.1** for descriptions of the various plans reviewed).

5.5.1 2035 Development Predicted by Collaborative Judgment Land Use Panel

Section 4.6.2 in the Indirect Effects chapter describes the collaborative work of the expert Land Use Panel in making projections of the potential induced growth related to the proposed US 281 Corridor Project, in the context of other land development projected to occur within the AOI as well as past growth reflected in current land developments. **Figure 4-6** from that discussion is reproduced here as **Figure 5-12**, with the addition of residential housing sector boundaries used in making projections of housing and population growth as described in **Section 5.5.2** .

The depiction of past and present (current) development in the Land RSA (equivalent to the AOI), shown as gray on **Figure 5-12** is based on 2008 aerial photography with updates from field reconnaissance and information from local experts.

Estimates of other reasonably foreseeable future development (shown as green on **Figure 5-12**) include (1) areas committed to development (in a darker shade of green), including approved subdivisions (Comal County) and areas with approved Master Development Plans (Bexar County); and (2) other areas considered by the Land Use Panel as likely to be subject to development by 2035 if identified infrastructural improvements *other than the US 281 Corridor Project* are completed (shown in a lighter shade of green).

Areas shown as yellow and white on **Figure 5-12** represent, respectively, areas subject to US 281-induced development and areas that are not projected to be developed by 2035.

Geographical Information Systems (GIS) acreage calculations for past, present, and reasonably foreseeable future development (gray plus green), as well as induced growth and undeveloped areas, are shown in **Table 5-6**. Acreages are also shown for undevelopable and/or development-constrained areas, like state parks, floodplains, and Canyon Lake (shown as orange on **Figure 5-12**).

Table 5-6: 2035 Development within the Land RSA Resulting from Other Past, Present and Reasonably Foreseeable Future Actions

Area	Acres[1]
Total Land RSA	356,550
Current (past/present) development (gray)	115,550
Other reasonably foreseeable future development unrelated to US 281 project (green)	70,620
Induced growth area (additional area subject to development with project) (yellow)[2]	16,980
Undevelopable and/or constrained areas (orange)	79,190
Not predicted to develop by 2035 (white)	74,200

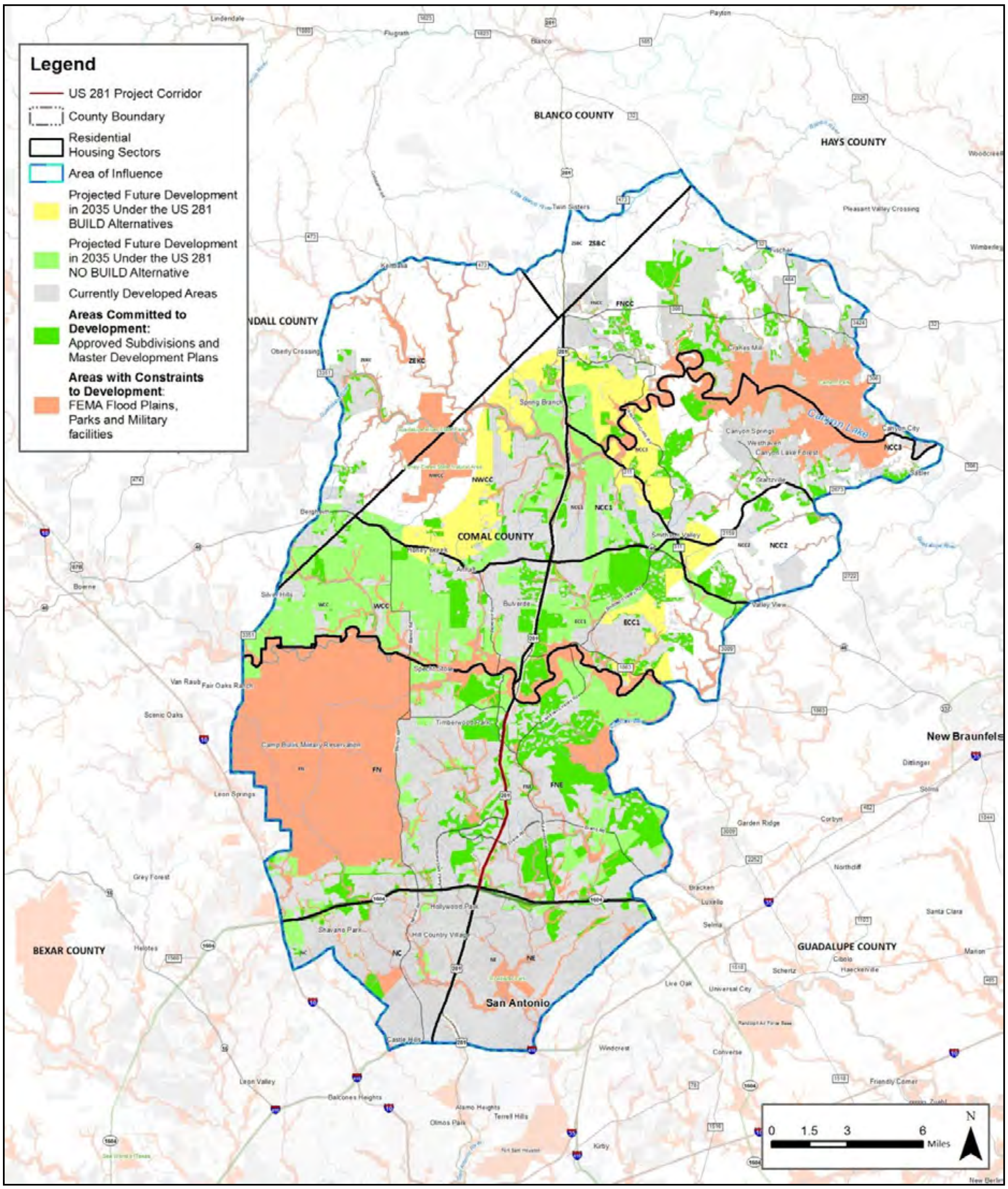
Source: US 281 EIS Team, 2011
1Approximate acreage, rounded to nearest 10 acres
2Generalized area where induced growth is projected to occur, without accounting for differences between proposed Build Alternatives.

5.5.2 2035 Development Estimate Based on Population Projections and Residential Absorption Analysis

To provide another perspective to compare with the collaborative judgment method reflected in the Land Use Panel's development projections, an alternative method was employed that distributed total population projections to the Land RSA, (equivalent to the AOI), which was subdivided into the residential housing sectors shown on **Figure 5-12**. The sources of population trends and projections used were from the Texas State Data Center (TSDC), which provides population information by county, and Environmental Systems Research Institute Business Information Solutions (ESRI), which provides population information by Census Tracts. The population projection and residential housing absorption analysis was performed for the US 281 Draft EIS by SA Research Corporation (2010), and is included in a more complete form as **Appendix M.**

In general, the residential housing absorption analysis corresponds to the area population projections that are summarized in **Table 4-3** in the AOI trends discussion of **Chapter 4 - Indirect Effects**. The overriding assumptions of this residential absorption analysis were that past rates of population growth and land development patterns observed in the Bexar-Comal-Kendall-Blanco four-county area and in the AOI from 2000 to 2009 will continue, with an adjustment made for the recent recession-related economic downturn.

Figure 5-12: Current and projected (2035) land development within the area of influence, showing residential housing sectors



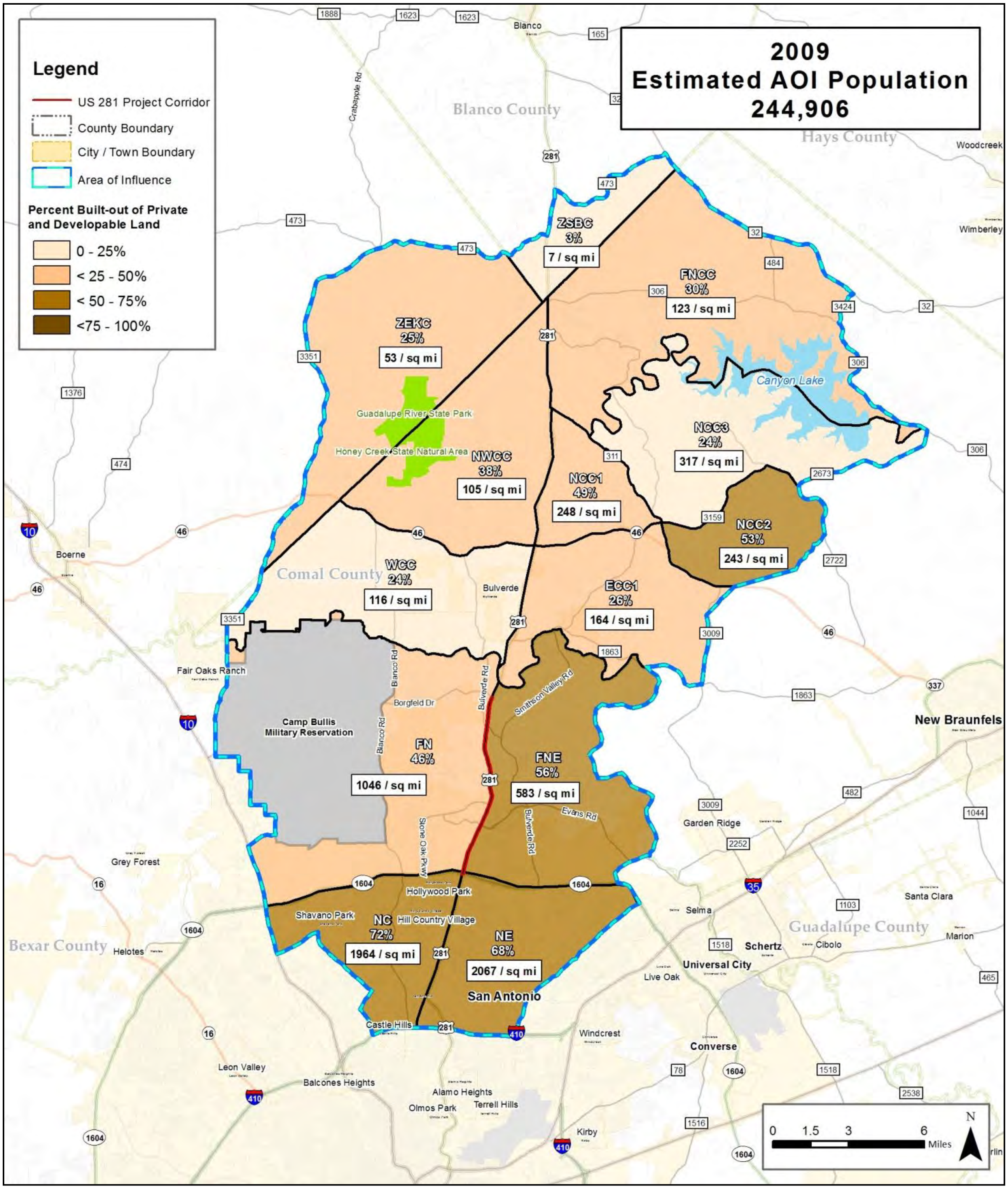
Source: US 281 EIS Team, 2010

As given in **Table 4-3**, the 2000 to 2009 annual population growth rate estimated for the four county area ranges from 1.3 percent to 2.2 percent, depending on which migration scenario is applied, and the rates projected for 2010 to 2035 decrease to 1.2 percent to 1.9 percent. Projections estimated for the AOI, made by aggregating or in some cases subdividing the Census Tract data available from ESRI, show a substantially faster rate of growth, estimated at a 6.4 percent annual increase in population from 2000 to 2009, with the AOI projected to grow at a 5.5 percent rate from 2010 to 2035. The SA Research Corporation's projections and the underlying assumptions do not incorporate any explicit influence related to the Proposed Build Alternatives as compared to the No-Build Alternative.

The residential housing analysis was based on land use information and county appraisal district codes designating private and exempt developed land, associated rights-of-way, vacant available (developable) land, constrained areas and other categories in order to identify areas that are built-out and parcels that are available for development. Then, based on a series of assumptions regarding development density, availability of water and wastewater service, platted and pending lots, the transportation network, household size, and other factors, projected population growth was interpreted as primarily single family residential development, and absorption of the available developable land was estimated, based on an assumed south-to-north pattern of growth. Population growth is projected annually, with residential housing sectors in the southern part of the AOI projected to become built out before 2035 (between 2010 and 2026). When a sector becomes built out, the excess residential housing demand is shifted to and absorbed by the neighboring sectors in a reasonably expected progression, generally from south to north.

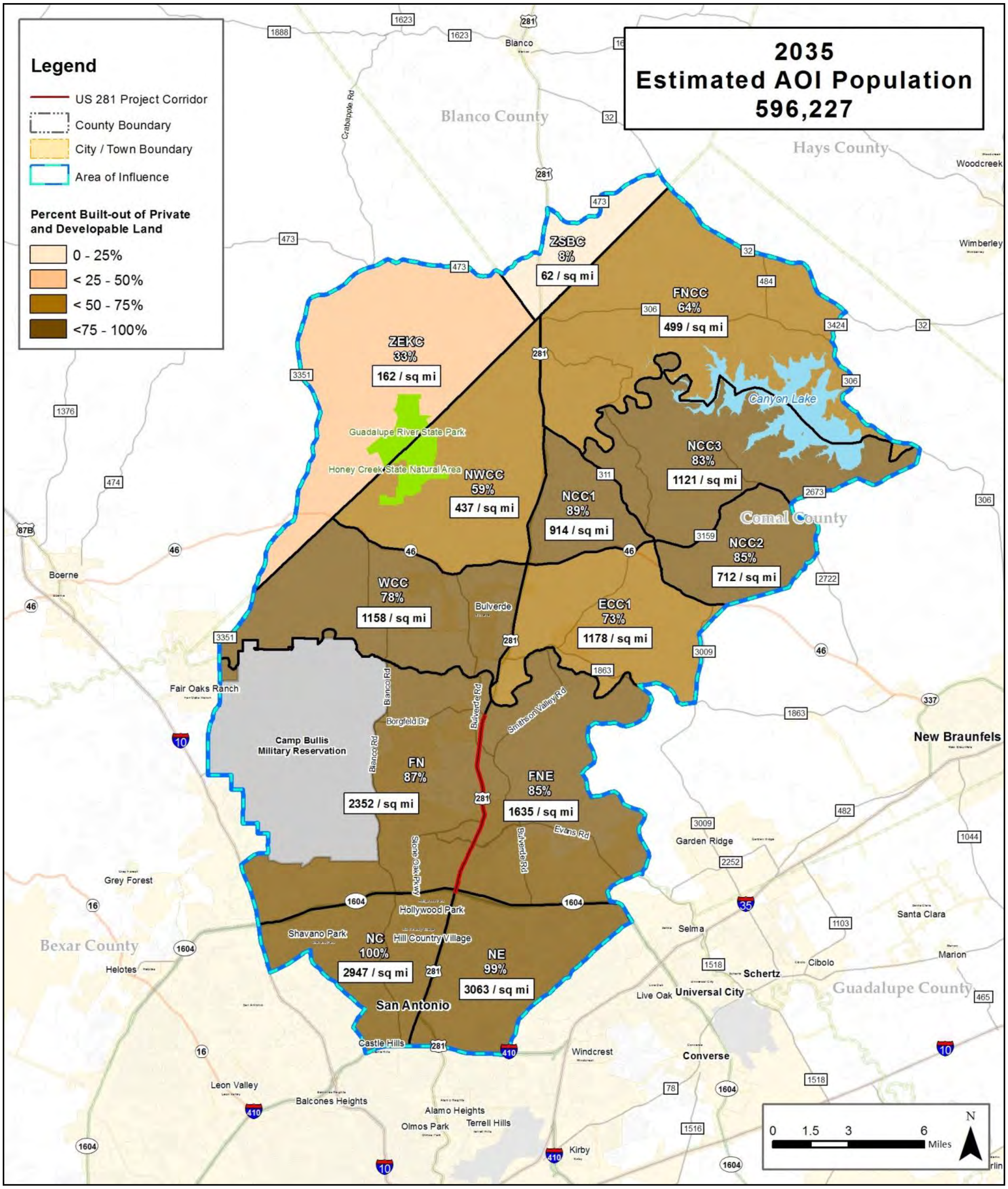
The overall results of this population and residential housing projection analysis are shown graphically in **Figure 5-13** and **Figure 5-14**, which present a comparison of 2009 and projected 2035 conditions in terms of the percent of private and developable land built-out and the population densities (persons per square mile) by sector. The estimated population for the entire AOI is projected to increase by a factor of 2.4 between 2009 and 2035, growing from 244,906 to 596,227 residents. The built-out percent of developable land in 2009 is estimated to range from three percent in the Blanco County sector to 68 and 72 percent in the northeast and north central San Antonio sectors. The 2009 population densities are estimated to range from seven persons per square mile in the Blanco County sector to 2,067 persons per square mile in the northeast San Antonio sector. The overall development scenario changes dramatically between 2009 and 2035, with the built-out percent of developable land increasing from eight percent in the Blanco County sector to 99 and 100 percent in the northeast and north central San Antonio sectors, and with 8 of 13 sectors becoming greater than 75 percent built-out, as compared to none of them exceeding 75 percent in 2009. The estimated population densities in the different sectors increased by factors of 1.5 to 10 times the 2009 levels, with some of the greatest proportional increases occurring in the sectors north of Cibolo Creek in southwest Comal County, where densities are projected to increase from 116 to 164 persons per square mile in 2009 to 1,158 to 1,178 persons per square mile in 2035.

Figure 5-13: Percent built-out and population density in 2009



Source: US 281 EIS Team, 2010

Figure 5-14: Percent built-out and population density in 2035



Source: US 281 EIS Team, 2010

5.5.3 Identified Individual Projects

Table 5-7 through **Table 5-9** present specific reasonably foreseeable actions that were identified as of summer 2010 within the Land RSA that have the potential to substantially influence cumulative land development effects on area resources. These actions are grouped as: Transportation Projects; Private and Public Land Development Projects; and, Infrastructure Projects.

Table 5-7: Current and Future Transportation Projects

Project Name	Development Entity (or Transportation Plan)	Project Description	Fiscal Year	Location
IH-10 W, Loop 1604 to S of Huebner Rd	TxDOT (in FY 2011-2014 STIP)	Expand six to eight lane Expressway and operational improvements	2011	IH-10, S of Huebner Road to Loop 410
US 281, 0.2 mi N of Loop 1604 to Bexar / Comal Co. Line (US 281 Corridor Project)	Alamo RMA (in FY 2011-2014 STIP)	Expand to six lane Expressway, with six new main lanes, outer lanes	2013	US 281, 0.2 mi N of Loop 1604 to Bexar / Comal Co. Line
Loop 1604, NW Military Hwy to Redland Road	Alamo RMA (in FY 2011-2014 STIP)	Expand from four to eight lane Expressway, with four new main lanes and outer lanes	2014	Loop 1604, NW Military Hwy to Redland Road
Loop 1604, SH 16 to NW Military Hwy	Alamo RMA (in FY 2011-2014 STIP))	Expand from four to eight lane Expressway, with four new main lanes and outer lanes, including connectors at IH-10	2013	Loop 1604, SH 16 to NW Military Hwy
Wurzbach Parkway Extension	TxDOT (in FY 2011-2014 STIP)	New Location four lane divided roadway construction.	2011	Wurzbach Parkway, segments from FM 2696 to Wetmore; inside Loop 1604
Austin-San Antonio Passenger Rail	ASAICRD / Lone Star Rail District (in FY 2011-2014 STIP)	Final Design, ROW, and Construction (platforms, stations, track)	2013 & 2014	Austin-San Antonio Rail Corridor
Salado Creek Bike Path	City of San Antonio (in FY 2011-2014 STIP)	Construct bike path	2013	Salado Creek, Blanco Road to Wetmore Road
US 281 Transit Facility (Park & Ride)	VIA Metro Transit (in FY 2011-2014 STIP)	Site Acquisition (Future Construction of Park & Ride Facility)	2014 (Apportionment Year for Land Acquisition)	
Northeast Transfer Center – Naco Pass	VIA Metro Transit (in SA-BC MPO STIP 2011-2014)	Site Acquisition (Future Construction of Transit Center	2011	Naco Pass
Loop 1604 @ US 281 Interchange Design- Build	Alamo RMA	Construct interchange with non-toll direct connectors	2010-2013 Construction	Loop 1604 @ US 281
US 281 Superstreet Project	Alamo RMA	Superstreet Concept Operational improvements	Constructed 2010	Various

Table 5-7: Current and Future Transportation Projects

Project Name	Development Entity (or Transportation Plan)	Project Description	Fiscal Year	Location
Bulverde Road Added Capacity	*Mobility 2035*	Widened and added lanes	2015 Expected Operational	Bulverde Road from Evans to Marshall
Bulverde Road Bicycle Lanes	*Mobility 2035*	Addition of bike lanes		Along Bulverde from Evans to Marshall
US 281	(Comal County Major Thoroughfare Plan)	Controlled Access Freeway		Bexar County line to Guadalupe River
SH 46, from FM 2722 to Comal/Kendall Co. Line	(Comal County Major Thoroughfare Plan)	Upgrade to Secondary and Primary Arterial		SH 46, from FM 2722 to Comal/Kendall Co. line except in incorporated areas
FM 306, FM 2793, FM 2722, FM 3159, FM 1863 (East of US 281), and FM 3351	(Comal County Major Thoroughfare Plan)	Upgrades to Primary Arterials		Various Locations in the AOI
FM 32, FM 311, and FM 484	(Comal County Major Thoroughfare Plan)	Upgrades to Secondary Arterials		Various Locations in the AOI
FM 1863 (West of US 281), FM 2696, Ammann Road, Smithson Valley Road, Rebecca Creek Road, Demi John Bend, and N Cranes Mill Road	(Comal County Major Thoroughfare Plan)	Upgrades to Collector Roads		Various Locations in the AOI

Source: SA_BC MPO, Comal County Engineer's Office, US 281 EIS Team 2011

Table 5-8: Current and Future Private and Public Land Development Projects

Project Name	Development or Planning Entity	Project Description	Build Timeframe	Location
Private Sector Land Development				
Bulverde Oaks	Various	Master Plan with > 19,000 SF lots total	Ongoing	Bulverde Road, N Bexar County
Four S Ranch		780 acre Master Plan with 1,800 platted lots	2010+	Smithson Valley Road, Comal County
Johnson Ranch		Master Plan, approx. 500 acres with 1,025 platted lots with retail center	2010+	E of US 281, N of FM 1863, Comal County
McCarty Ranch		Approx. 400 acres	TBD	W of US 281, N of FM 1863, Comal County
Unnamed Subdivision		Approx. 3,000 acres	Partially Built/Ongoing	NW of Ammann Road @ FM 1863
River Crossing		Major Commercial	Partially Built/Ongoing	Spring Branch

Table 5-8: Current and Future Private and Public Land Development Projects

Project Name	Development or Planning Entity	Project Description	Build Timeframe	Location
The Crossing at 46		Commercial	Partially Built/Ongoing	SH 46 @ US 281
Public Sector (Schools) Land Development Projects				
Smithson Valley High	Comal ISD	Extensive renovation and expansion; capacity 2,575 students	2009 – 2011+	SH 46, W of FM 3159
Smithson Valley Middle School	Comal ISD	Expansion; capacity 1,150 students	2010	FM 311 N of SH 46
Spring Branch Middle School	Comal ISD	Expansion; capacity 1,150 students	2010	SH 46, W of US 281
Rahe Bulverde Elementary	Comal ISD	New school facilities for additional space and to combine 2 existing schools; capacity 824 students	2010	E Ammann Road
New Elementary at Indian Springs	Comal ISD	New school; capacity 824 students	2011	SE of Smithson Valley Road @ Bulverde Road
New High School, new Middle School & new Elementary School at Kinder Tract	Comal ISD	Up to 3 new schools	2011+	Borgfeld at Bulverde Road
Possible New Elementary	Northeast ISD (Per Feb 2009 article in SA Bus Journal NEISD purchased 21-acre tract for new school);	New school to be developed on 21-acre tract in Bulverde Oaks	2010+	Near Bulverde Road
Boerne Schools: Samuel V. Champion High, New Elementary, Land Acquisition	Boerne ISD	No current expansion projects; New schools developed 2008-2009; Last bond measure including $2 million to acquire land for future campuses		Various

Source: US 281 EIS Team, 2011

Table 5-9: Current and Future Actions – Infrastructure Projects

Project Name	Development or Planning Entity	Project Description	Build Timeframe	Location
Bulverde Regional Water Master Plan	Canyon Lake Water Service Company	Plan to provide domestic water service to numerous parcels in southern Comal County	Undetermined/ Ongoing	Between Bexar County line in south, Kendall County line in west, FM 3009 in east, & areas to the north of SH 46
Storage Above Canyon Reservoir	GBRA	An Aquifer Storage & Recovery system (ASR) program or off-channel reservoir (OCR)	Implemented prior to 2020	Canyon Reservoir

Table 5-9: Current and Future Actions – Infrastructure Projects

Project Name	Development or Planning Entity	Project Description	Build Timeframe	Location
Western Canyon WTP Expansion	GBRA	Future expansion of the Western Canyon WTP	Implemented prior to 2050 per TWDB Region L Plan	Western Canyon WTP
Lower Guadalupe Water Supply Project for Upstream GBRA Needs	GBRA	Water management strategy to supply WTPs in the AOI by diversion of underutilized water supply from the Lower Guadalupe Basin	Alternative water management strategy for possible implementation in the 2011 SCTRW Plan; (Not included in Recommended Plan)	Lower Guadalupe Basin
Edwards Aquifer – Carrizo/Wilcox Aquifer Transfers (Twin Oaks ASR)	SAWS	An operational Aquifer Storage and Recovery (ASR) program involving transfers between the two aquifers	Operational, ongoing	SAWS Service Area
Edwards Aquifer Recharge Initiative -Type 1 and Type 2 Projects	SAWS, with GBRA, SARA, EAA, USACE Nueces RA, City of Corpus Christi also for Nueces Basin	Edwards Aquifer recharge enhancement from upstream runoff detention (Type 1) and temporary channel impoundments (Type 2)	Cibolo: 2010+ Nueces: 2012+	Cibolo Watershed Nueces River Basin
Western Canyon WS for SAWS	SAWS, GBRA, Cities of Boerne, Fair Oaks, Bulverde, and Johnson Ranch, Cordillera Ranch, Tapatio Springs/ Kendall County Utility Co., and Comal Trace Subdiv.	Utilization of water supply from Canyon Lake; includes Winwood Tank and Oliver Ranch water storage facilities	Ongoing	Participating cities and developments in Bexar, Comal, and Kendall Counties
Trinity Aquifer WS for SAWS	SAWS, Oliver Ranch, Bulverde Sneckner Ranch	Provides water supply to SAWS from Trinity Aquifer withdrawals; augments water supply for most of the AOI	Contract terms through 2024	Serves large area N of Loop 1604 and West of US 281
Brackish Ground Water Desalination	SAWS	Treatment of water from the brackish zone of the Wilcox Aquifer	Potential operations 2011+	SAWS Service Area
Regional Carrizo Water Supply	SAWS	Development of a pipeline to transfer water supply from Gonzales and Wilson Counties	2015	SAWS Service Area
Ocean Desalination	SAWS	Long term strategy is under study	2035 – 2060	SAWS Service Area

1 Source: US 281 EIS Team 2011

5.5.4 Summary of Current and Other Reasonably Foreseeable Future Development

The following assessment of cumulative effects on the different resource categories relies heavily on the reasonable expectations and projections of land development and growth that has been presented in this section. The graphical depictions of growth and development scenarios (shown in **Figure 5-12, Figure 5-13,** and **Figure 5-14)** reflect general consistency between two independent and different methods of projecting growth-related land development. This consistency provides a level of confidence that each method tends to convey upon the other. The collaborative judgment method depicted in **Figure 5-12** provides more location-specific information within the general growth areas confirmed by the residential housing sector-based analysis. Subsequent analyses of potentially affected resources will combine this information on general locations where growth has occurred and is considered likely to occur in the future with location-specific resources to draw conclusions about the locations and degree of cumulative effects.

5.6 STEP 6: IDENTIFY AND ASSESS CUMULATIVE IMPACTS

For each of the resources or issues evaluated, expected effects of past, current, and reasonably foreseeable future actions were combined with direct and indirect impacts associated with each of the Proposed Build Alternatives to evaluate the cumulative effects on the health, stability, and sustainability of discussed resources. Resources are analyzed in the larger context of the RSAs identified, but the assessment of effects, including quantifications, is focused on the area in which effects of the proposed US 281 Corridor Project will be felt, which is the AOI. The assessment is largely qualitative, but effects are quantified and summarized in tables where it is reasonable to do so. The assessment assumes that resource protection measures required by state, local and federal regulations or policies (**Sections 5.8.1**) will be enforced. Additional mitigation measures are addressed in **Section 5.8.2** .

5.6.1 Cumulative Effects on Land Resources and Land Uses

Cumulative effects are defined as the impact on the environment which results from the incremental impacts of the proposed US 281 Corridor Project when added to other past, present and reasonably foreseeable future actions. The cumulative effects evaluation focuses on the contextual relationship between the proposed US 281 Corridor Project's predicted direct and indirect effects and the overall pattern of future land development in the Land RSA (equivalent to the AOI) as estimated by the US 281 EIS Land Use Panel and the residential absorption analysis. This relationship is illustrated in **Table 5-10** which summarizes the quantitative estimates of various categories of land use and development effects. Based on the collaborative judgment of the US 281 EIS Land Use Panel, the 2035 development predictions are also differentiated by Proposed Build Alternative. With these calculations as a baseline of expected land development, other specific resources are evaluated in more detail in subsequent sections.

Table 5-10: Total Projected 2035 Land Development in Land RSA (acres)

	No-Build Alternative (as % of Total Land RSA)	Expressway Alternative (as % of Total Land RSA)	Elevated Expressway Alternative (as % of Total Land RSA)
Total Land RSA	356,547	356,547	356,547
Not Developable[1]	79,194 (22%)	79,194 (22%)	79,194 (22%)
Currently Developed	115,551 (32%)	115,551 (32%)	115,551 (32%)
Currently Potentially Developable	161,801 (45%)	161,801 (45%)	161,801 (45%)
Direct Effects	NA	128 (<1%)	99 (<1%)
Indirect Effects			
Encroachment Alteration	NA	Not quantified	Not quantified
Induced Growth[2]	NA	18,574 (5%)	19,096 (5%)
Project-Related Development (Direct + Indirect Effects)	NA	18,702 (5%)	19,195 (5%)
Other Reasonably Foreseeable future Actions	70,621 (20%)	70,621 (20%)	70,621 (20%)
Total Projected 2035 Land Development	186,172 (52%)	204,874 (58%)	205,367 (58%)

Source: US 281 EIS Team, August 2010
[1]Includes surface area of Canyon Lake
[2]Area within which indirect development effects are likely to occur

Quantified indirect effects represent development associated with the proposed US 281 Corridor Project in the judgment of the expert land use panel and the EIS analysts. The reported indirect effects area does not represent a footprint of predicted development, but rather the area within which future development is likely to occur. Precise locations and densities would be subject to development conditions and assumptions which cannot be precisely determined at present. This level of increased urbanization would result in substantial future land use change, with accompanying alterations to existing ecological, hydrological, and aesthetic conditions. The following sections address the degree to which these effects are likely to be substantially adverse, beneficial, or of no effect, based on the current status/viability of the resources and the nature of the interaction between the resources. It should also be noted that within the Land RSA, there are approximately 74,200 acres (21 percent of the RSA) that are not projected to develop by 2035, in addition to approximately 71,000 acres of lands considered to be undevelopable (including park lands) or with constraints to development (including floodplains). Cumulative effects could occur throughout an area encompassing more than 50 percent of the Land RSA under all of the Proposed Build Alternatives. The project's direct and indirect effects account for about nine percent of the total predicted cumulative effects.

This note serves primarily to discourage a heavy reliance on the quantification of effects: it does not diminish the overall probability that substantial future development is likely to occur in the Land RSA, both with and without the proposed project. **Table 5-10** shows that potential cumulative effects could occur over more than 50 percent of the Land RSA under all of the Proposed Build Alternatives. Even under the No-Build Alternative, 2035 land development is estimated to exceed 50 percent of the Land RSA.

5.6.2 Effects on Socioeconomic and Community Resources

Population Growth and Residential Development

The land development and residential growth estimates for the year 2035 described in **Section 5.5** are consistent in predicting a substantial population increase and land use change within the Land RSA/AOI and the Hill Country area north of San Antonio. The growth rates observed for the four-county area from 2000 to 2009 will continue, at 1.2 percent to 1.9 percent annually, adjusted somewhat for the recent (2008-2010) economic downturn. Projections for the AOI indicate a much faster rate of growth – about 5.5 percent annually. **Figure 5-13** and **Figure 5-14** present population growth by AOI sector. Total population is expected to grow from 244, 906 persons in 2009 to 596,227 persons in 2035, an increase of 351,321 persons (143 percent). Population densities will increase dramatically in the middle AOI sectors. Sector WWC, located west of US 281 between Camp Bullis and SH 46, shows a 2009 density of 116 persons/square mile. By 2035 the density in this sector will increase nearly ten-fold to 1,158 persons/square mile. The SA Research projections indicate that residential development in that sector, which in 2010 was about 24 percent built-out, will be about 78 percent built-out by 2035. Another sector facing considerable developmental change is Sector ECC1, east of US 281 between SH 46 on the north and FM 1863 on the south. Population density in this sector is expected to grow from 164 persons/square mile to 1178 persons/square mile between 2009 and 2035, a seven-fold increase. For comparison, the densities projected for sectors WCC and ECC1 in 2035 will be just slightly higher than the current (2009) population density in sector FN, which lies adjacent and to the west of the proposed US 281 project corridor, between Loop 1604 and the Bexar County line. Only the far north sectors covering small portions of Blanco and Kendall Counties are not predicted to experience substantial growth by 2035. Kendall County Sector ZEKC and Blanco County Sector ZSBC retain low population densities (162 persons/square mile and 62 persons/square mile, respectively) in 2035 (SA Research 2010).

Environmental Justice; Vulnerable Elements of the Population

The overview of the socioeconomic and demographic composition and distribution (2000, 2008, 2010) within the Socioeconomic and Community RSA presented in **Section 5.3.2** demonstrated that the project AOI does contain readily identifiable EJ populations and other concentrations of vulnerable elements of the community, such as elderly or disabled citizens; however, they are not likely to be adversely affected by direct, indirect, or cumulative land use and developmental changes associated with the proposed project. Census Tracts that had greater than 50 percent minority composition in 2010 are located south of Loop 1604, mostly in areas of fully developed neighborhoods. These areas are beyond the influence of direct project effects, and encroachment-alteration indirect effects have not been specifically identified. Induced growth was not projected for these areas by either the Land Use Panel or the population-residential growth analysis (**Section 5.5** **).** Although the 2035 growth projections for the AOI do not specifically address the socioeconomic or demographic composition of the future AOI population, there is no evidence that the composition is likely to be substantially different from the existing population profile. Based on the experience of the past decade of growth in the area between Loop 1604 and the Bexar County Line (Sectors FN and FNE on **Figure 5-13** and **Figure 5-14**) it is not unreasonable to expect that median incomes will increase and percent minority will remain stable in the high growth sectors immediately north of Bexar County (Sectors WCC and ECC1).

Potential Tolled and Managed Lanes Effects on EJ Populations

The effects of the potential tolled or managed lane options associated with either of the Proposed Build Alternatives on EJ populations within and beyond the AOI are addressed in the following section, which is based on the 2011 project-level report in **Appendix E** and regional-level report in **Appendix F**.

Project Background and Policy Guidelines

The US 281 Environment Impact Statement (EIS) evaluates the impacts of improvements to the US 281 project corridor between Loop 1604 and Borgfeld Drive. The corridor is approximately eight miles long and is currently a four lane highway with primarily at-grade intersections along its length.

Two Proposed Build Alternatives were developed for consideration for the US 281 Corridor Project that contain a toll component. According to FHWA and TxDOT joint guidance, proposed toll facilities must undergo an evaluation to determine anticipated effects on EJ populations within the region, including the impacts to travel time and/or out-of-pocket cost.

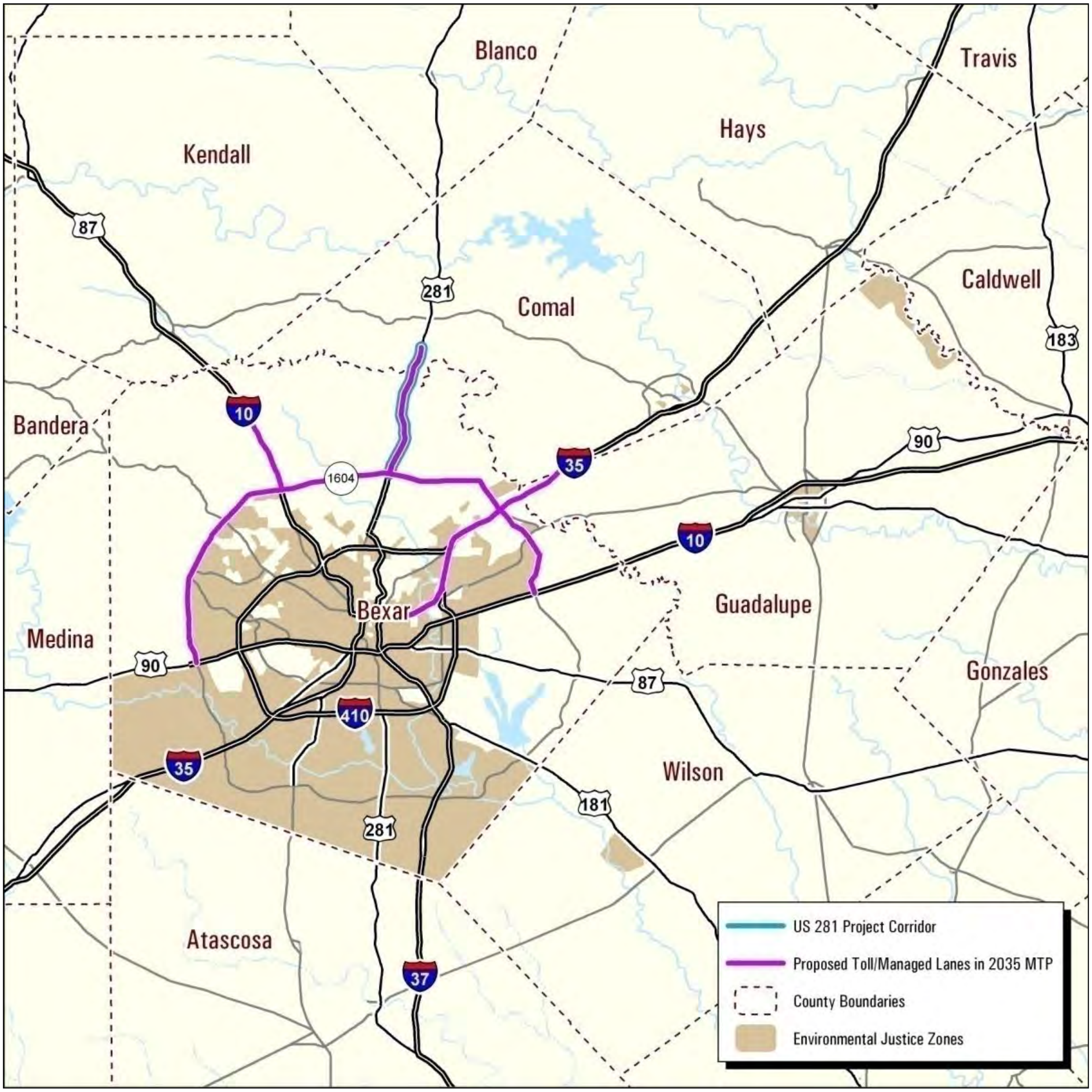
No tolled or managed roadways are currently operational in the region, but the SA-BC MPO has identified several corridors as planned toll and/or managed facilities by the year 2035, including the northern half of Loop 1604, IH-35 east of downtown, IH-10 north of Loop 1604, and the study corridor – US 281 north of Loop 1604. These planned facilities are generally situated away from the concentrated EJ zones.

Environmental Justice Data

The San Antonio region (including Bexar, Comal, Guadalupe, Kendall and Wilson counties) has a large EJ (minority and/or low-income) population. About 64.6 percent of the overall regional population qualifies as EJ, according to the 2010 Census the MPO area is a majority minority region. The 2009 FHWA/TxDOT joint guidance for toll facilities recommends a threshold of 50 percent to identify areas with EJ populations. This analysis is consistent with the 50 percent recommendation. Consistent with the *SA-BC MPO Regional Toll and Managed Lane Analysis* (July 26, 2010), any Traffic Analysis Zone (TAZ) with an EJ population percentage greater than or equal to 50 percent was identified as an EJ zone.

There are 638 EJ zones in the San Antonio region out of a total of 1,136, and these EJ zones are projected to contain 1.41 million residents by the year 2035, out of a total regional population of about 3.94 million. The zones identified as having 50 percent or more minority and low-income population are mostly concentrated in the southern part of the region. **Figure 5-15** shows the planned toll/managed facilities in the region and identifies the EJ zones.

Figure 5-15: Proposed toll facilities and EJ zones



Source: SA-BC MPO Regional Toll and Managed Lane Analysis, July 26, 2010

Description of Proposed Toll Facility

Several alternatives were proposed for the US 281 Project Corridor. The alternatives development and screening process described in the Draft EIS resulted in the selection of two Proposed Build Alternatives, both of which have variations that include toll and/or managed lanes. In addition to the Proposed Build Alternatives, the No-Build Alternative was evaluated. For the purpose of this analysis, the Build Alternative that accommodated the greatest number of trips through the US 281 project corridor was selected as a basis for comparison. This is the Expressway Alternative. The EJ analysis presented herein focuses on the comparison of the No-Build Alternative, Expressway Non-Toll, and the Expressway Toll, each of which was evaluated in detail throughout the DEIS process. These alternatives are discussed in the next sections.

No-Build Alternative

The No-Build Alternative is defined for the US 281 EIS as the existing roadway facility, together with committed improvement projects as planned by the SA-BC MPO outside of the specific action being proposed. The 2035 network provided by the SA-BC MPO was used as the base for the No-Build Alternative network. This 2035 network includes widening and upgrading US 281 to a tolled expressway in the study area. For this project analysis, this improvement was removed and US 281 was re-coded to conditions as in the 2008 model to form the No-Build network.

Expressway Alternative – Non-toll

Three options for the Expressway Alternative were considered: A) Non-toll, B) Toll, and C) Managed Lanes. The Non-toll option was determined to attract the greatest demand for US 281 trips and includes three expressway through-lanes plus one auxiliary lane in each direction throughout the project corridor.

Expressway Alternative– Toll/Managed Lanes

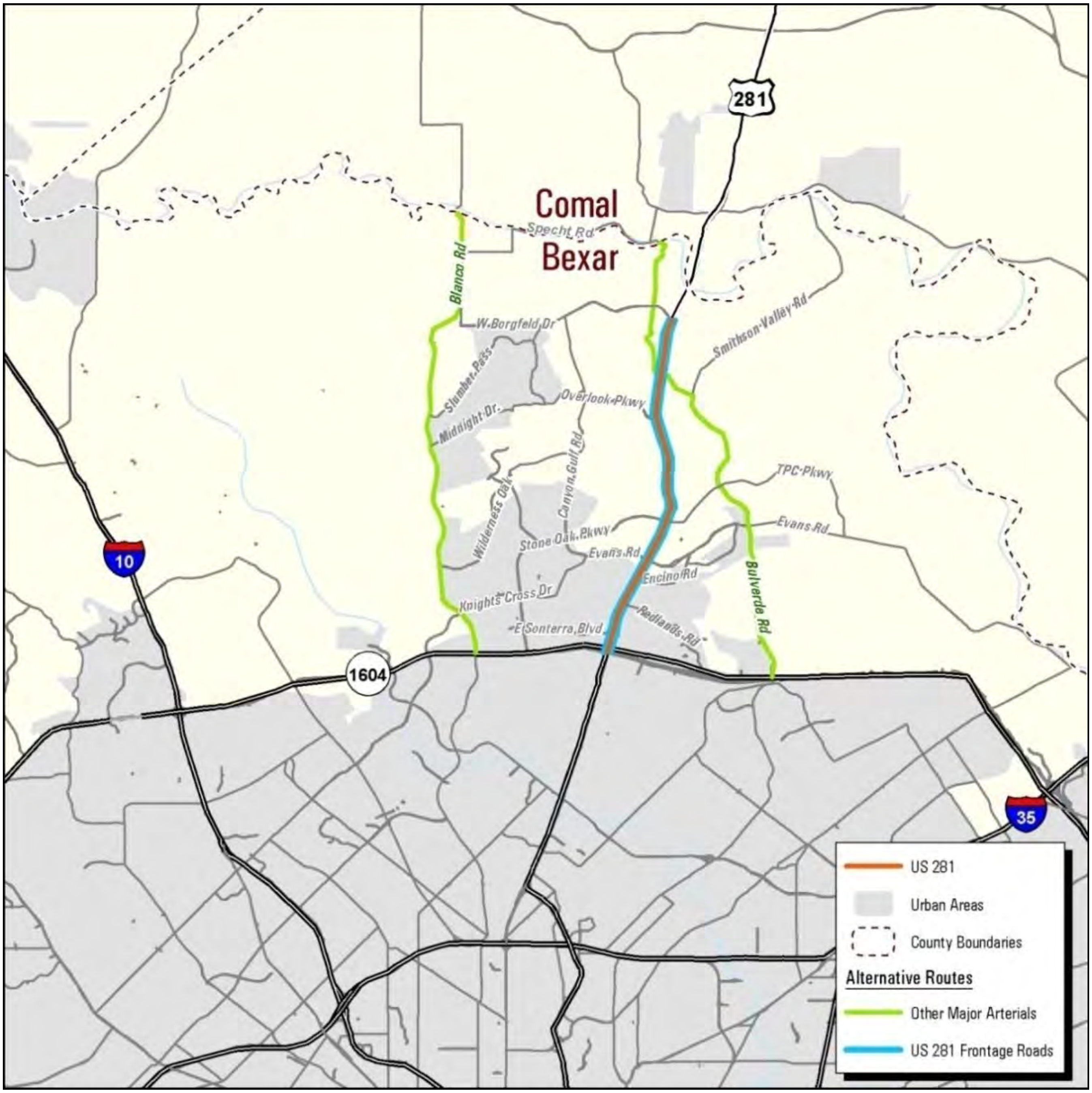
The Expressway Alternative – Toll/Managed Lanes is the same configuration as the Expressway Alternative – Non-toll, but the expressway is designated as a toll facility. The toll policy – including potential accommodations for minority, disabled, or low-income populations – would follow the guidelines outlined in the *SA-BC MPO Regional Toll and Managed Lane Analysis* (June 26, 2010). The toll guidelines would include policies regarding outreach to minority and disabled communities to allow full access to the toll facility, including websites in Spanish and a customer service number for the hearing disabled population. Toll collection would be conducted with electronic transponders or similar technology. Policies regarding purchases of toll tags by low-income populations are not planned or adopted yet, but would follow guidelines specified in the *SA-BC MPO Regional Toll and Managed Lane Analysis*. For preliminary analysis, toll gantries might be constructed at the following locations:

- Between Redland Road and Encino Rio
- Between Evans Road and Stone Oak Parkway
- Between Mountain Lodge and Wilderness Oak
- Between Trinity Park and Borgfeld Drive

Alternate Routes

In the study area, alternate routes would be available to those unable or unwilling to use the toll facility. First, a frontage road system would be constructed directly adjacent to the toll facility. This system would include a minimum of two lanes in both directions of travel and would provide local access along the corridor as well as access to and from the tollway. In addition to the frontage roads, two primary alternate routes exist in the vicinity of the project: Bulverde Road to the east and Blanco Road to the west. Each of these facilities is planned to be at least two lanes in each direction, and would operate as principal arterials in most of the study area. These alternate routes are displayed in **Figure 5-16**. In addition to these alternate routes, the local street network, including roads like Stone Oak Parkway and Canyon Golf Road, could be utilized.

1 Figure 5-16: Alternate routes



2

3 Source: US 281 EIS Team, 2011

For the identification of potential trips using the corridor and the analysis of the travel time impacts on those trips, the SA-BC MPO Regional Travel Demand Model was utilized. The travel model provides travel demand volume projections at a daily level. It also produces estimates of trip origins and destinations, as well as congested roadway travel times. The SA-BC MPO model uses input parameters including speed and travel time based on observed congested – or peak hour – conditions. The model assigns trips to roadways under these peak conditions, and reports forecasted peak hour speeds and volume-to-capacity (v/c) ratios, and daily traffic volumes.

As with any simulation model, there are limitations to its capabilities. The model has a basic procedure for estimating toll road volume, which is traffic assignment based. The toll procedure adds a cost in terms of travel time by converting an assumed toll rate per mile with value-of-time assumptions, for links coded as toll links.

For a complete summary of the application of the travel demand model for the US 281 EIS, see **Appendix D**.

The model was used to determine "candidate" trips for the corridor – or trips that would use the proposed facility because it would provide the fastest route. These candidate trips were determined by isolating the corridor and identifying trip origin and destination pairs (TAZs) that use any segment along the corridor. The candidate trips were selected using the "free" build alternative because it attracts the most travelers on the corridor – it provides increased roadway capacity at no additional cost to the traveler.

Subsequently, each candidate trip origin-destination (O-D) pair was analyzed to determine the travel time between those TAZs. This process calculates the congested travel time along the best (shortest time) possible route, and was conducted for the following scenarios:

- 2035 No Action
- 2035 Expressway Alternative – Non-Toll
- 2035 Expressway Alternative – Toll/Managed Lanes
- 2035 Expressway Alternative – Toll/Managed Lanes - Free Path (Alternate Routes & Frontage Roads – using the Toll Alternative but excluding paths that utilize the US 281 Main Lanes)

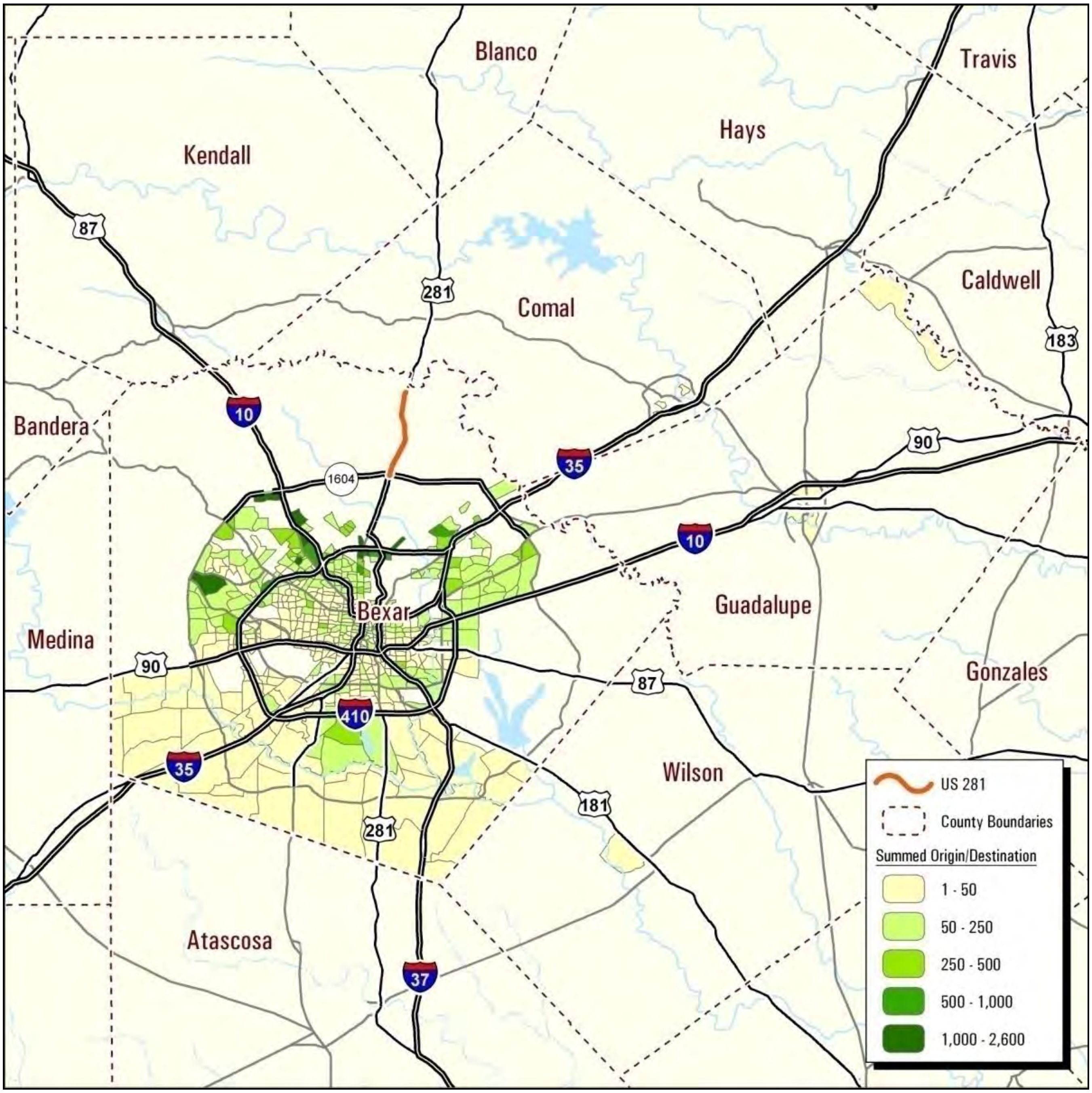
Results Summary

Out of 9.2 million daily trips made in the five county region modeled by the SA-BC MPO, approximately 211,000 are projected to use US 281 in 2035. These are considered the candidate trips, and 75,000 of them are projected to either begin or end in an EJ zone. **Figure 5-17** presents the EJ zones with trips that use US 281 and the number of trips that begin or end in each zone.

Travel Time Analysis

Because of the location of the corridor in the northern reaches of the San Antonio region, trips that use the corridor are generally longer than average for the region, because services and employment opportunities are further away. The average trip distance for all trips in the region is approximately 9 miles, compared to approximately 22 miles for candidate trips. The average trip time in the No-Build Alternative is 97 minutes for all candidate trips, and 106 minutes for EJ candidate trips since EJ zones are located further away from the US 281 project corridor. Both of the Proposed Build Alternatives result in improved travel times for all users, including EJ trips. In the Expressway Alternative – Non-toll, all candidate trips, including EJ travelers would experience a reduction of 14 to 16 minutes in travel times. In the Expressway Alternative – Toll/Managed Lanes, users on the tolled facility would experience a reduction of 14 to 17 minutes in travel times depending on the toll rate. Users who were either unable or unwilling to pay the toll would still experience a reduction of 4 to 9 minutes in travel times on the free paths (alternate routes and frontage roads), as traffic on those parallel facilities would be reduced and speeds increased as a result of the improvements to the US 281 project corridor. The free alternate routes and frontage roads are of equal distance as the tolled path; all tolled Alternatives would include frontage roads parallel to the tolled main lanes. **Table 5-11** summarizes the changes in travel times for the analysis year of 2035. Note that trips that are not identified as candidate trips are slightly impacted (positively) by the inclusion of either Proposed Build Alternative. These are trips that use other roadways in the area that are relieved by the US 281 improvements.

Figure 5-17: Environmental justice zones that are projected to use US 281



Source: US 281 EIS Team, 2011

Table 5-11: Environmental Justice Analysis Results

	Candidate Trips		All Other Trips	
	All	EJ Trips	All	EJ Trips
Number of Trips in 2035	211,200	75,400	8,995,100	5,871,700
No-Build Alternative				
Average Time	97	106	28	26
Expressway Alternative – Non-Toll				
Average Time	83	90	28	26
Time Savings per Trip compared to No Build (minutes)	14	16	0	0
Total Time Savings compared to No Build (hours)	50,000	19,500	28,000	7,000
Expressway Alternative – Toll/Managed Lanes - Tolled Path*				
Average Time	81-83	89-91	28	26
Time Savings per Trip compared to No Build (minutes)	14-16	15-17	0	0
Total Time Savings compared to No Build (hours)	49,500-55,500	18,500-20,500	11,500-20,000	500-6,000
Expressway Alternative – Toll/Managed Lanes - Free Path*				
Average Time	89-93	97-102	28	26
Time Savings per Trip compared to No Build (minutes)	4-8	4-9	0	0
Total Time Savings compared to No Build (hours)	15,500-29,000	5,000-10,5000	8,000-14,000	0-5,000

* Range represents travel time and savings based on toll rates of 17 cents, 32 cents, and 50 cents per mile.
Source: Appendix E, US 281 EIS Team, 2012

The results demonstrate that an overall decrease in travel time is experienced by travelers in 2035 from EJ zones, compared to the scenario of not implementing the US 281 Corridor Project (No Build). Travelers from EJ zones would realize travel time benefits that are similar in magnitude to the travel time benefits of all users when using the same path. The findings of this analysis are consistent with the findings of the SA-BC MPO *Regional Toll and Managed Lane Analysis* (July 26, 2010).

As the price of the toll increases, fewer people will pay which means that the toll path will be less congested, improving travel times for those using it. Travelers unwilling or unable to pay the toll will divert to alternative free paths resulting in greater congestion and fewer travel time benefits for those travelers. However, regardless of the pricing scenario, all travelers would benefit from improved travel times under both Proposed Build Alternatives, compared to the No Build Alternative.

Cost Analysis

The *Amended and Restated Policies and Procedures for Toll Collection Operations on the Alamo RMA Turnpike System* (April 2012) outlines tolling policies for the US 281 corridor and other proposed regional toll facilities. The updated policy proposes tolling prices ranging from $0.17 per mile to $0.50 per mile. The upper and lower values of this range, as well as a mid-range ($0.32 per mile) were analyzed. **Table 5-12** presents potential financial obligations under each of these tolling scenarios, based on median household incomes for families living within the region.

Table 5-12: Environmental Justice Cost Analysis

Toll Cost per mile	Daily Round Trip Cost	Yearly Cost	Percent of Median Household Income		
			Bexar County ($45,315)	Comal County ($62,642)	Poverty Line ($19,090)
$0.17	$2.72	$680	1.5%	1.1%	3.6%
$0.32	$5.12	$1,280	2.8%	2.0%	6.7%
$0.50	$8.00	$2,000	4.4%	3.2%	10.5%

Source: Appendix E, US 281 EIS Team, 2012, U.S. Census Bureau, 2005-2010 American Community Survey

While EJ populations may spend a greater portion of their income on tolls, as shown above, alternate (free) routes are available in the Expressway Alternative – Toll/Managed Lanes that provide improved travel times to the No Build Alternative, and would provide a net benefit to EJ and Non-EJ communities.

There were no EJ block groups based on income identified within the demographic study area and because the project will enhance the overall functionality and mobility of the existing non-tolled transportation network as well as any future transit service, it is anticipated that low-income travelers would not experience a disproportionately high and adverse human health and environmental effect as a result of either Proposed Build Alternative.

Quality of Life Effects on Adjacent Neighborhoods and Outlying Communities

The Indirect Effects analysis (see **Section 4.5.1**) concluded that encroachment-alteration effects of the proposed US 281 Corridor Project, through possible changes of travel patterns or access or localized effects of business displacements are not expected to be substantial. Visual and aesthetic effects on project area neighborhoods were found to be potentially substantial, particularly for the Elevated Expressway Alternative (Non-toll, Toll and Managed Lanes). These effects are described more fully in **Section 4.6.1.**

The Socioeconomic and Communities RSA includes 18 communities or identified populated places within the AOI that are beyond the corporate limits of San Antonio; these places are profiled at **Section 5.3.2** . The Indirect Effects analysis identified five of these places – Honey Creek, Anhalt, Spring Branch, Rebecca Creek Road Neighborhood, and Smithson Valley – that are located within the “induced growth” area – the area within which the Land Use Panel predicted US 281 Corridor Project-related development is likely to occur. That assessment (see **Section 4.6.3**) concluded that the socioeconomic and community effects related to induced growth on those five communities are not likely to be substantial given that they tend to be diffused populations whose community identifications are largely historical and geographic, rather than linked to specific urban elements or public spaces; most have been experiencing and adjusting to the spread of San Antonio’s urban growth for many years.

Of the 13 remaining profiled communities, six are within the area identified as likely to be affected by other reasonably foreseeable future development. Startzville and Sattler to the south and east of Canyon Lake are in partially built up areas which have approved subdivisions located in infill areas. Timberwood Park, Bergheim, and Silver Hills are located in areas in which the Land Use Panel projected new development by 2035. Bulverde is also in a growth area and has an approved Comprehensive Plan. As with the communities within the induced growth area, the six communities within areas likely to be affected by other reasonably foreseeable future development have long been adapting and would likely continue to adapt to the urban growth of San Antonio. The identities of these communities, rooted in history and geography rather than present-day urban elements or physical spaces, would not be expected to deteriorate as a result of continued growth. Other Canyon Lake communities like Canyon Springs, Westhaven, and Canyon Lake Forest are in largely developed areas south of Canyon Lake.

5.6.3 Cumulative Effects on Water Resources

Surface Water

Direct impacts to surface waters from any of the Proposed Build Alternatives would occur primarily in the Salado Creek drainage area, with a minor amount at the northern tip of the project corridor in the Cibolo Creek drainage area (**Figure 4-8**). The indirect effects related to induced development within the AOI would occur in the upper Guadalupe River, Canyon Lake, Cibolo Creek and Dry Comal Creek drainage areas, as shown on **Figure 4-8**; these effects were discussed in more detail in **Section 4.6.4**. Indirect encroachment-alteration effects were discussed in **Section 4.6.1**. In this section, these direct and indirect effects are addressed in the context of the cumulative effects that are reasonably likely to affect the same water resources. **Table 5-13** provides a summary of the cumulative land development within the Land RSA that may result in water quality impacts to surface waters. When the previously noted effects of the US 281 Proposed Build Alternatives are added to the other past, present, and reasonably foreseeable future actions that are unrelated to the US 281 Project, the extent of cumulative land development in most of the drainage areas indicate a substantial potential for cumulative water quality impacts that would likely be associated with this land development and population growth.

Table 5-13: Cumulative Land Development within Surface Water Drainage Areas of the Land RSA (Acres)

Build Alternative	Currently Developed	US 281 Direct Impacts[1]	Induced Development (Area of Potential Indirect Impacts)	Project-Related Development (as % of Total Cumulative Development)	Reasonably Foreseeable Future Development (Unrelated to the Project)	Cumulative Development (% of Land RSA[2])
Expressway Alternative (Non-toll, Toll and Managed Lanes)	115,551	128	18,574	18,702 (9%)	70,621	204,874 (57.5%)
Elevated Expressway Alternative (Non-toll, Toll and Managed Lanes)	115,551	99	19,096	19,195 (9%)	70,621	205,367 (57.6%)

Source: US 281 EIS Team, 2011
[1]Additional ROW
[2] Total Acreage of Land RSA = 356,547 acres

Direct impacts to water crossings within the RSA from both of the Proposed Build Alternatives are summarized in **Table 5-5** and are discussed in **Section 3.10**. Indirect, encroachment-alteration impacts associated with the Proposed Build Alternatives would include the effects of stormwater runoff discharged from the roadway, including discharges of bacteria, nutrients, heavy metals, petroleum hydrocarbons, increased turbidity and siltation of receiving waters, as well as possible spill-related contaminant releases that could degrade downstream water quality and aquatic habitats. The construction of bridges and culverts or other drainage alterations within the ROW could affect stream channel and flow dynamics upstream and downstream of the roadway, within permitted limits. Sedimentation in local waterways could increase during the construction phase, and post-construction runoff volumes would generally be expected to increase with addition of impervious cover. Water quality degradation would be limited through the implementation of BMPs and other water quality controls. Municipal separate storm-sewer systems (MS4) could be affected by the need to accommodate altered flows and/or address sedimentation effects in local waterways.

In terms of cumulative effects, future development could lead to higher risk for water quality degradation from point and non-point source pollutant loading within sub-watersheds of the affected drainage areas. Projected population growth will likely lead to further urbanization of some area watersheds, and new suburban and urban land uses in other watersheds that currently have primarily rural land uses. Increases in impervious cover associated with future development is likely to alter the timing and quality of runoff and lead to increased pollutant loads in affected streams and in Canyon Lake reservoir. **Figure 5-11** indicates that about 58 percent of the AOI, has been, currently is, or will be subjected to some degree of residential, commercial and/or industrial development. For perspective, note that the Surface Water RSA (1.1 million acres) is about three times the size of the AOI (356,000 acres). As discussed in **Section 5.5** , such development is expected to be associated with increases in human population density, and, throughout much of the AOI, a conversion of rural land uses and open space to suburban and urban land uses. The expected increase in residential, commercial and public buildings, recreational facilities, parking lots, sidewalks, and roads will result in an increase of impervious surfaces, known as impervious cover. Changes in the extent of impervious cover has important influences on the hydrologic regime that affects the way rainfall infiltrates into the ground and runs off into surface drainage courses and natural water bodies, and also changes the quality of stormwater runoff.

Research studies conducted over the past three decades have consistently shown an inverse relationship between the extent of impervious cover in a watershed and stream health in terms of water quality, stream channel morphology, and the condition of aquatic biological communities and aquatic habitat. Numerous investigators have found that water quality and receiving water ecosystem impacts occur when watershed impervious cover exceeds about 10 percent, and that such degradation proceeds along a continuum that becomes most severe and persistent at watershed imperviousness of about 25 percent (Schueler 2000; Dietz and Clausen 2008; Wang et al. 2001; Kaufman and Brant 2000; and Booth et al. 2001). Other investigators have studied the relationship between human population density and impervious cover (Exum et al. 2005). As explained in **Section 4.6.3**, this analysis of development-related water quality effects in the US 281 study area considers 10 percent impervious cover to be the point at which probable impacts are expected, and this level of impervious cover is most likely associated with population densities of 500 to 900 persons per square mile or higher. A more detailed discussion of the relevant research findings and the relationship between human population density and impervious cover is provided in **Section 4.6.3**.

The cumulative land development that is projected to occur by 2035 will not affect the different drainage areas and waterbodies in a uniform manner. The extent to which the drainage areas of the AOI are affected by the different categories of past and future land development is summarized in **Table 5-14**, which also shows the extent of lands not projected to develop by 2035 and lands considered undevelopable or development-constrained.

Table 5-14: Different Categories of Current and Projected Land Development within the Drainage Areas of the AOI (acres)

Affected Drainage Area (Acreage in AOI)	Induced Development (Area of Potential Impacts)		Currently Developed	Reasonably Foreseeable Future Development (Unrelated to the Project)	Undevelopable and/ or constrained lands	Lands not projected to develop by 2035
	Expressway	Elevated Expressway				
Blanco River (12,037 acres)	0	0	1,163	160	185	10,528
Upper Guadalupe River (95,720 acres)	13,674	14,072	19,061	11,339	12,725	39,972
Canyon Lake (39,458 acres excluding the waterbody)	367	432	16,158	4,607	5,569	13,142
Guadalupe River below Canyon Dam (5,817 acres)	0	0	1,380	316	311	3,809
Dry Comal Creek (12293 acres)	1,440	1,539	1,344	2,438	810	6,465
Cibolo Creek (85,518 acres)	3,002	3,053	21,427	38,784	21,169	270
Leon Creek (591 acres – all Camp Bullis)	0	0	0	0	591	0
Upper San Antonio River (10,145 acres)	0	0	7,297	1,785	1,048	15
Salado Creek (87,459 acres)	0	0	47,721	11,189	28,546	3
Total for all drainage areas in AOI:	18,574	19,096	115,551	70,621	70,194	74,203

Source: US 281 EIS Team, 2011

As indicated in **Table 5-14** and illustrated on **Figure 4-8**, the drainage areas and waterbodies most affected by the past, present and future cumulative land development within the AOI are Cibolo Creek, Salado Creek, and the upper San Antonio River, with substantial cumulative development-related effects also projected to occur in the upper Guadalupe River and Canyon Lake drainage areas. The Guadalupe River below Canyon Dam, Dry Comal Creek, and especially the Blanco River has large proportions of their drainage areas within the AOI that are not projected to develop by 2035. Cumulative development-related effects in the upper San Antonio River and Salado Creek drainages are mostly associated with past development, as reflected in the currently developed acreage, although the Salado Creek watershed has over 11,000 acres of future development projected that is unrelated to the US 281 Corridor Project. As previously noted, indirect project effects related to induced growth are limited to the upper Guadalupe River and Canyon Lake drainage areas, and to a lesser extent the Cibolo Creek and Dry Comal Creek drainages; direct effects would only occur in the Salado Creek and Cibolo Creek watersheds. According to the CEQ regulations, cumulative effects are defined as environmental impacts that result from "…the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions…" (40 CFR 1500-1508). Thus, land development effects in the drainage areas of the Blanco River, the Guadalupe River below Canyon Dam, Leon Creek, and the upper San Antonio River are not, strictly speaking, relevant to the findings of this US 281 Corridor Project analysis because there are no direct or indirect project-related effects in these drainage areas.

The population densities that have been forecast for 2035 in the different parts of the AOI, shown in **Figure 5-14**, are indicative of the levels of impervious cover that may be expected to accompany the projected development. In the Cibolo Creek, Salado Creek, and the upper San Antonio River, and in parts of the drainage areas for the upper Guadalupe River and Canyon Lake, these forecast population densities would be expected to result in future levels of impervious cover greater than 10 percent, which indicates probable substantial cumulative water quality impacts in these waterbodies and/or their tributaries. In the Salado Creek and the upper San Antonio River drainage areas, current population densities indicate that 10 percent impervious cover has probably been exceeded, and in fact widespread impairment in these streams reflects this urbanization effect. In the case of Cibolo Creek, the Mid Cibolo Creek segment, at the southeast corner of the RSA and downstream of the AOI, has been listed as impaired by the TCEQ since 2000 for one or more water quality parameters. This impairment most likely reflects the generalized effects of urbanization in its watershed as well as certain point sources of pollution. Part of the Upper Cibolo Creek segment, in the area in and around Boerne that is affected by land development in addition to agricultural land uses, has been listed as impaired for one or more parameters since 2000. Both Cibolo Creek segments continue to be listed for bacteria impairment in the 2010 303(d) list, but have been de-listed for other impairments including depressed dissolved oxygen.

In summary, cumulative water quality effects are expected to occur as a result of induced growth and also other reasonably foreseeable future development, in combination with past land development. For the oak-juniper uplands woods/forest, project-related development is expected to contribute about 15 percent of the total cumulative development. The relative contribution of project-related development to the total cumulative development that may affect the riparian woods and forests vegetation type is 14 percent. These proportions do not vary by proposed build alternative. The level of impact of these cumulative effects will depend on the successful implementation of federal, state, and local water quality regulatory programs and successful planning, design and implementation of additional mitigation measures.

Groundwater

There is a potential for water quality effects to the Edwards Aquifer related to cumulative land development within the AOI, and in particular related to the effects of stormwater runoff from that development. The two potential pathways for contamination whereby stormwater runoff from developed land that may impact water quality in the aquifer are: (1) stormwater from developed areas within the drainage areas upstream of the Edwards Aquifer Recharge Zone that is transported to the Recharge Zone within and downstream of the AOI by streams such as Salado Creek, Cibolo Creek and Dry Comal Creeks; and, (2) the potential for direct recharge of the aquifer by contaminants in stormwater from development occurring over the Edwards Aquifer Recharge Zone. As discussed in **Section 4.6.4**, the upper Guadalupe River and Canyon Lake drainage areas within the AOI, while within the watersheds of the Edwards Aquifer Contributing Zone, are not considered to be effective contributing areas for the purposes of this water quality analysis, because of the overwhelming influence of Canyon Dam on water quality characteristics. The dam and reservoir influence water quality through detention, settling and accumulation processes that store and/or substantially alter pollutants before the water is released below Canyon Dam. The other drainage areas within the AOI are not affected by major dams, and these drainages may effectively contribute to the quality of water recharging the Edwards Aquifer, including the Cibolo Creek, Dry Comal Creek, the Guadalupe River below Canyon Dam, Salado Creek, the upper San Antonio River, Leon Creek and the Blanco River drainage areas.

The potential for groundwater quality effects related to cumulative land development affecting the different zones of the Edwards Aquifer within the AOI are summarized in **Table 5-15.** Although the RSA for groundwater extends over the entire geographical area of the southern segment of the Edwards Aquifer, the quantitative evaluation of data on cumulative development effects was limited to that portion of the aquifer that was within the AOI.

Table 5-15: Cumulative Land Development (acres) within the AOI that has Potential to Impact Water Quality of the Edwards Aquifer

Edwards Aquifer Zones	Currently Developed	US 281 Direct Impacts, (Total ROW/ additional)	Induced Development (Area of Potential Indirect Impacts)	Reasonably Foreseeable Future Development (Unrelated to the Project)	Cumulative Development	Total AOI Areas[1]
Expressway Alternative (Non-toll, Toll and Managed Lanes)						
Recharge Zone	32,080	408/94	610	16,250	49,040	69,760
Upstream Areas that Affect Edwards Aquifer Water Quality	24,790	105/34	3,830	36,720	65,370	114,270
Elevated Expressway Alternative (Non-toll, Toll and Managed Lanes)						
Recharge Zone	32,080	389/75	690	16,250	49,100	69,760
Upstream Areas that Affect Edwards Aquifer Water Quality	24,790	94/23	3,910	36,720	65,440	114,270

Source: US 281 EIS Team, 2011
[1] Total AOI areas include undevelopable and development-constrained land (approximately 15,420 acres on the Recharge Zone and 33,580 acres in upstream drainage areas that affect Edwards Aquifer water quality), and lands that are not projected to develop by 2035 (approximately 5,560 acres on the Recharge Zone and 41,810 acres in upstream drainage areas that affect Edwards Aquifer water quality).

Direct impacts to groundwater quality are described in **Section 3.10.2** and encroachment-alteration effects are discussed in **Section 4.6.1.** These effects are associated with construction activities, structures and impervious surfaces, and drainage regimes within the project corridor; direct effects are relatively minor in comparison to the overall cumulative development acres summarized on **Table 5-15**.

There is a potential for cumulative effects to groundwater supplies in the Edwards and Trinity aquifers within the Groundwater RSA as a result of the high rate of population growth, as discussed in **Section 5.5** and the associated increases in water demand, particularly for new and expanded residential areas. The expected increase in water demand is addressed in the on-going regional and state water planning efforts (SCTRWPG 2010). From these studies water strategies have been identified that, if implemented, would meet the demand for water supplies through the year 2030. Cumulative effects will not be substantial if water supply and demand projections and related assumptions used in the regional water planning process remain valid. Meeting future water demand in the region assumes that at least 320,000 acre-feet of groundwater will be available annually from the southern (San Antonio) segment of the Edwards Aquifer even during conditions equivalent to the drought of record. This does not include any droughts of longer duration or frequency that have been predicted by climate change models.

Probable cumulative water quality effects to groundwater are expected to result from the combination of induced development and other land development within the AOI. Effects related to induced development will add incrementally to the cumulative risk of water quality degradation from point and non-point source pollutant loading to streams that recharge the Edwards Aquifer in the Cibolo Creek and Dry Comal Creek drainage areas. Other AOI watersheds that can contribute water quality effects to the Edwards Aquifer via recharge, including lands draining to the Blanco River, Guadalupe River below Canyon Dam, Salado Creek, and the upper San Antonio River, are not affected by induced development (see **Figure 4-8**). The relative extent of US 281 Corridor Project-induced development in the Cibolo Creek and Dry Comal Creek drainage areas, as compared to the other components of cumulative effects, is reflected in **Table 5-14**. Induced development projected to occur in the contributing drainage areas (upstream of the Recharge Zone) that may affect Edwards Aquifer water quality totals 3,830 acres for the proposed Expressway Alternative (Non-toll, Toll and Managed Lanes), and 3,910 acres for proposed the Elevated Expressway Alternative (Non-toll, Toll and Managed Lanes). These induced development areas represent approximately six percent of the total cumulative land development acreage (approximately 65,000 acres) in the contributing drainage area within the AOI that may affect Edwards Aquifer water quality. As noted in **Section 4.6.4**, the total induced development area that is projected to occur over the Edwards Aquifer Recharge Zone is 610 acres for the Expressway Alternative (Non-toll, Toll and Managed Lanes) and 690 acres for the Elevated Expressway Alternative (Non-toll, Toll and Managed Lanes). These are considered to be minor, but not inconsequential, amounts of development area relative to 49,040 acres cumulative development over the recharge zone for the Expressway Alternative (Non-toll, Toll and Managed Lanes) and 49,100 acres for the Elevated Expressway Alternative (Non-toll, Toll and Managed Lanes). As a proportion, the induced development area that is projected to occur over the Edwards Aquifer Recharge Zone is approximately one percent of the cumulative development acreage within the AOI. Considering its proportional contribution, the induced development component of cumulative effects to

Edwards Aquifer water quality is not considered to be substantial, while the cumulative water quality effects to the aquifer from all past, present and future land development in the AOI are substantial.

According to the CEQ regulations, cumulative effects are defined as environmental impacts that result from "…the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions…" (40 CFR 1500-1508). Thus, land development effects in the drainage areas of the Blanco River, the Guadalupe River below Canyon Dam, Leon Creek, and the upper San Antonio River may potentially affect the Edwards Aquifer via stream channel recharge but effects related to these drainage areas are not, strictly speaking, relevant to the findings of this US 281 Corridor Project analysis because there are no direct or indirect project-related effects in these drainage areas. The main focus of this groundwater quality evaluation, therefore, is on cumulative effects related to development in the Cibolo Creek, Dry Comal Creek and Salado Creek drainage areas.

In summary, cumulative water quality effects to groundwater in the Edwards Aquifer are expected to occur as a result of past land development in combination with reasonably foreseeable future development that is unrelated to the US 281 Corridor Project, with proportionally minor incremental effects associated with US 281 Corridor Project-induced development and with localized impacts from direct and encroachment-alteration effects of the proposed project. Such cumulative effects are expected to occur in the Cibolo Creek and Salado Creek drainage areas of the AOI, and to a lesser extent in the Dry Comal Creek drainage area. The level of impact of these cumulative effects will depend on the successful implementation of federal, state, and local water quality regulatory programs and successful planning, design and implementation of additional mitigation measures. The incremental effects of the US 281 Corridor Project -induced development are expected to play a relatively minor, but not inconsequential role in terms of the overall water quality impacts to groundwater.

5.6.4 Cumulative Effects on Ecological Resources

Vegetation and Wildlife

Cumulative land development associated with impacts to vegetation and wildlife habitat within the US 281 Area of Influence is summarized in **Table 5-16**. This analysis is based on the extent of different vegetation types within the study area, as shown on **Figure 5-5**, and information on where current and projected future development areas occur in relation to these vegetation types. **Table 5-16** indicates that direct impacts to vegetation and wildlife habitat from all of the Proposed Build Alternatives would be minimal. However, indirect effects and other reasonably foreseeable future actions, when added to direct impacts, are expected to result in probable substantial cumulative effects. The types of expected effects include habitat fragmentation for resident wildlife and migratory birds, as well as the loss and other alteration of vegetation cover types and wildlife habitat.

1 **Table 5-16: Cumulative Effects by Vegetation Types (acres)**

Vegetation Cover Type	Direct Impact		Induced Development (Area of Potential Impact)		Currently Developed	Reasonably Foreseeable Future Development[2] (Unrelated to the project)	Undevelopable and/or constrained lands	Lands not projected to develop by 2035	Cumulative Development – Area of Potential Impacts	
	Exp. Alt.	Elevated Exp. Alt.	Exp. Alt.	Elevated Exp. Alt.					Exp. Alt.	Elevated Exp. Alt.
Oak-Juniper Upland Woods/Forest	0	0	11,626	11,988	26,141	40,748	33,648	45,598	78,515	78,877
Grasses and Forbes	0	0	3,531	3,606	9,438	12,786	13,262	16,641	25,756	25,830
Oak-Juniper-Elm Upland Parks & Woods	121	97	40	40	58	120	434	85	339	315
Riparian Woods and Forests	0	0	424	438	1,014	1,696	6,692	2,015	3,134	3,148
Oak-Juniper-Mesquite Shrub/Brush		0	2,384	2,441	11,705	7,894	6,525	7,549	21,982	22,040
Sparsely Vegetated /Urban	135	138	432	442	32,846	3,061	4,067	1,987	36,474	36,487
Crops	0	0	135	139	81	722	642	294	938	942
Water	0	0	1	1	71	11	8,331	17	83	83
Swamp	0	0	0	0	0	0	4	.2	0	0
Total[3]	256	235	18,573	19,095	81,354	67,038	73,603	74,186	166,359	167,730

SOURCE: TPWD Texas Ecosystems Classification Project and US 281 EIS Team 2010.
[1] Represents total acreage of areas within which potential indirect impacts could occur. Total acreage and actual locations of surface disturbance related to induced growth is not known at present.
[2] Represents total acreage of areas within which other reasonably foreseeable future development could occur. Total acreage and actual locations of surface disturbance related to other reasonably foreseeable future development is not known at present.
[3] Total acreage shown for categories differs from acreage totals in Tables 5-11 and 5-13 because of reduced area within the AOI/Land RSA for which the vegetation type data is available – see Figure 5-5.

Cumulative effects including past, present, and future actions within the vegetation and wildlife RSA have historically had adverse effects on wildlife habitat and associated populations through conversion of established native plant associations to urban and suburban landscapes. **Table 5-17** shows the proportions that each of the vegetation types mapped in **Figure 5-5** comprise of the total land areas within the AOI as well as the larger Vegetation and Wildlife RSA. **Table 5-17** also shows the proportion that each vegetation type within the AOI makes up of larger extent of the vegetation types in the Vegetation and Wildlife RSA. Estimated cumulative land development could potentially affect roughly 50 percent of the oak-juniper uplands woods/forest vegetation type within the AOI, and roughly 27 percent of the riparian woods and forests vegetation type within the AOI. As previously noted, project-related development is expected to account for nine percent of the total cumulative development in the Land RSA, but the relative contribution of project-related development varies by watershed, as shown in Table 5-14. There is no project-related development in the Blanco River, Guadalupe River below Canyon Dam, Leon Creek, or Upper San Antonio River drainage areas within the Land RSA. In the remaining drainage areas, the proportion of project-related to total projected cumulative development ranges from two percent in the Canyon Lake drainage area to 32 percent of cumulative effects in the Upper Guadalupe River drainage area of the Land RSA. (About two-tenths of one percent of the cumulative development projected in the Salado Creek drainage area would result from the project's direct effects.) The magnitude of potential land development effects within the larger RSA cannot be estimated due to a lack of development projections outside of the AOI; however it is noted that the AOI accounts for about 17 percent of the oak-juniper uplands woods/forest vegetation type within the RSA, and only about one percent of the total extent of the riparian woods and forests vegetation type mapped within the RSA.

Table 5-17: Acreage of Vegetation Types in AOI in Relation to Extent of Vegetation Types within the Vegetation and Wildlife RSA

Vegetation Cover Type	Acres in AOI	As Percent of Total AOI	Acres in Vegetation/ Wildlife RSA	As Percent of Total RSA	AOI acres as Percent of Vegetation/Wildlife RSA Acres
Oak-Juniper Upland Woods/Forest	156,721	50.0	470,179	49.9	16.6
Grasses and Forbes	55,398	17.7	216,779	23	5.9
Oak-Juniper-Elm Upland Parks & Woods	734	0.2	5,193	0.6	0.1
Riparian Woods and Forests	11,803	3.8	37,948	4	1.3
Oak-Juniper-Mesquite Shrub/Brush	35,838	11.4	113,641	12	3.8
Sparsely Vegetated/Urban	42,365	13.5	82,845	8.8	4.5
Crops	1,865	0.6	6,459	0.7	0.2
Water	8,430	2.7	9,142	1	0.9
Swamp	4	0.0	4	0.0	0.0
Total	**313,158**	**100.0**	**942,190**	**100.0**	**33.2**

Source: TPWD Texas Ecosystems Classification Project and US 281 EIS Team 2011
[1] Differs from Land RSA/AOI acreage in Table 5-11 and 5-13 because of reduced area within the AOI for which the vegetation type data is available – see Figure 5-6.

Wildlife habitat of higher quality (native prairies, mature and old growth woodlands) continues to decline in favor of more fragmented, younger, less diverse vegetation communities in both uplands and in riparian corridors. Such alterations have effected wildlife species composition, distribution, and abundance, with a trend toward increases in those wildlife species that are adaptable to human disturbance and proximity; in addition to a decline in those species that occur in larger, undisturbed tracts. Aquatic habitats have also been altered with continuing risk of reduced hydrological and ecological integrity.

While established native vegetation and associated wildlife resource populations are considered stressed and will continue to decline as a result of future development, this trend is expected to be ameliorated to some degree by on-going and planned land conservation and habitat preservation efforts identified in **Section 5.8** .

Threatened and Endangered Species

Surface Water Aquatic Species - Mussels
These species are state-listed threatened and under review for federal listing as threatened or endangered. They use varying substrates in flowing streams and rivers and can be negatively affected by pollutants, excessive sedimentation, flooding and drought. At this time, relatively little is known about their range-wide abundance, distribution or population dynamics. As a group, the freshwater mussels are likely to be studied more intensively over the coming years to gain more critical conservation information. Given existing regulatory protections provided to habitats associated with rivers and streams and associated floodplains, it is reasonable to assume that cumulative effects to this group of species would not be substantial. Their relatively recent state-listing provides some level of incentive for further research, monitoring and protection. If listed federally, this incentive would be even greater.

Surface Water Aquatic Species – Cagle’s Map Turtle
Populations of the turtle are considered “unevenly distributed and minimal” in the upper stretch of the Guadalupe River basin between its headwaters and New Braunfels (Killebrew et al., 2002). This upper portion of the river is estimated to support roughly 11 percent of the population. The vast majority of the population (perhaps greater than 80 percent) is found in the middle stretch of the Guadalupe River roughly between New Braunfels and Victoria. More specifically, the turtle is not likely to occur at all below Canyon Lake through five Guadalupe river impoundments (Lakes Dunlap, Placid, Starke Park, McQueeney and Meadow Lakes) which are downstream of New Braunfels (Killebrew et al., 2002).

Given the relative paucity of turtles present in the AOI, i.e., the upper portion of the Guadalupe River basin, and the distance to densely populated areas, cumulative effects to this species are not anticipated to be substantial. As with other Guadalupe River basin dependent species, development-related impacts pose water quality and flooding-related threats to the watershed. The existing regulatory framework that affords protection to waters of the US, floodplains and river beds will lessen potential cumulative effects on this species to some extent, but continued monitoring of the species and its habitat throughout its range will be necessary.

Aquifer Species - Invertebrates, Salamanders and Fish
Cumulative adverse effects due to either of the Proposed Build Alternatives on the

aquifer and spring dependent species that are federally-listed as Endangered or Threatened (Texas blind salamander, San Marcos salamander, fountain darter, San Marcos gambusia, Comal Springs riffle beetle, Comal Springs dryopid beetle, Peck's Cave amphipod, and Texas wild-rice) could occur if either the quantity or quality of water from the aquifer were to decline substantially as a result of induced development and other reasonably foreseeable future actions. Water demand from future development through the year 2030 is expected to be met by the development and implementation of additional water supplies. Efforts to protect springflow are underway through the Edwards Aquifer Recovery Implementation Program (EARIP) (see **Section 4.2**) and related mandatory critical period pumping reductions established by the EAA (**Section 4.2**). If these efforts are successful over the long term, substantial adverse cumulative effects associated with the proposed US 281 Corridor Project on the quantity of water needed to sustain these aquifer- and spring-dependent species are not expected to occur.

Cumulative effects from induced growth and other reasonably foreseeable future actions are expected to increase risk of water quality degradation in the Edwards Aquifer **(**see **Section 5.6.3)**. Because springflow that supports the aquifer species results from water discharged from the aquifer, the quality of springflow will be directly affected by the quality of the water in the aquifer and the quality of the surface water that recharges the aquifer. Adverse cumulative effects on water quality in the aquifer could similarly adversely affect the quality of springflow and the spring-dependent species. Such effects are difficult to quantify. **Section 5.6.3** provides a more detailed examination of water quality issues related to cumulative development. The severity and extent of these cumulative effects will depend on the success of federal, state, and local water quality regulatory programs; success of the design, construction, and maintenance of water quality protection measures; continued and expanded efforts by non-governmental organizations and private landowners to protect and improve critical watershed areas; and the resiliency of the species to contaminants that may enter the aquifer and eventually travel to the spring discharge locations.

Terrestrial Karst Invertebrate Species

In the context of cumulative effects analysis, concerns about the viability of karst invertebrate populations fall into four categories. The current focus in the San Antonio area is on (1) the designated critical habitat of listed karst species. In addition, there are concerns with (2) listed species potentially occupying known but un-surveyed karst features/caves as well as (3) rare and un-described species occurring in known and/or un-surveyed karst features/caves. Lastly, given the inherently hidden nature of this habitat, there are (4) potential features that can only be discovered when investigated prior to development in the Karst Invertebrate RSA. It should also be noted that areas for which right-of-entry was not granted at the time of survey were not investigated; therefore, determinations regarding karst invertebrate species within these areas cannot be made at this time. In the face of these uncertain scenarios, it is worth restating some basic facts: (1) no occupied endangered karst invertebrate habitat was discovered in the surveys completed in the fall of 2010 within a 500-foot buffer from the proposed project ROW (see **Section 3.16.2**); (2) no critical habitat or known occurrences of listed species have been identified in Comal County, where all project–induced and most other reasonably foreseeable development within the Land RSA is expected to occur; and (3) a smaller but still substantial area of Bexar County lies within Karst Zones 1 or 2 and has been identified as subject to other reasonably foreseeable future development by 2035 (see **Figure 5-6** and **Figure 5-12**). No attempts have been made to quantify cumulative effects to terrestrial karst invertebrates or their habitat. However, given the breadth of potential impact scenarios described above, the direct, indirect, and other reasonably foreseeable future effects on karst habitat could be substantial.

Endangered Birds

Golden-cheeked Warbler

Potential golden-cheeked warbler habitat loss associated with the cumulative effects of the proposed US 281 Corridor Project is a widely expressed concern. The warbler's preferred habitat of mature woodlands is doubly vulnerable: as a vegetation assemblage that takes a long time to regenerate and as an attractive location for human occupation. The judgment of the US 281 EIS Land Use Panel and the residential development analysis were consistent in their views of the future of the roughly 356,547-acre Land RSA, primarily in the Hill Country north of the project area: development is going to occur in areas that will affect potential GCWA habitat. The location, extent, and pace of these impacts are not established with certainty. The quantifications of indirect and cumulative impacts to potential GCWA habitat should be understood as GIS calculations based upon the integration of the professional judgments of land use experts and the opinions of wildlife biologists based on habitat models, vegetation maps and field observation.

As discussed in the previous section, potential GCWA acreages were calculated using (1) a predictive GCWA habitat model (Diamond 2007) and (2) TPWD Texas Ecological Systems (TES) (2010) vegetation classes that generally fit vegetation components used by the warbler. The TPWD TES vegetation class polygons selected included:

- Edwards Plateau Limestone Savanna and Woodland
  - Edwards Plateau: Ashe juniper motte and woodland (1)
  - Edwards Plateau: deciduous oak/evergreen motte and woodland (3)
  - Edwards Plateau:oak/hardwood motte and woodland (4)
  - Edwards Plateau: post oak motte and woodland (5)
- Edwards Plateau Dry-Mesic Slope Forest and Woodland
  - Edwards Plateau: Ashe juniper slope forest (7)
  - Edwards Plateau: live oak slope forest (8)
  - Edwards Plateau: oak/Ashe juniper slope forest (9)
  - Edwards Plateau: oak/hardwood slope forest (10)
- Edwards Plateau Mesic Canyon (not mapped but quantitatively included in the above categories)
  - Edwards Plateau bigtooth maple mesic canyon
  - Edwards Plateau mixed deciduous mesic canyon
- Edwards Plateau Floodplain Terrace
  - Edwards Plateau: floodplain Ashe juniper forest (37)
  - Edwards Plateau: floodplain liveoak forest (38)
  - Edwards Plateau: floodplain hardwood/Ashe juniper forest (39)
  - Edwards Plateau: floodplain hardwood forest (40)
  - Edwards Plateau: floodplain Ashe juniper shrubland (41)
- Edwards Plateau Riparian
  - Edwards Plateau: riparian Ashe juniper forest (37)
  - Edwards Plateau: riparian live oak forest (38)
  - Edwards Plateau: riparian hardwood/Ashe juniper forest (39)

- o Edwards Plateau: riparian hardwood forest (40)
- o Edwards Plateau: riparian Ashe juniper shrubland (41)

Figure 5-7 illustrates Diamond C and TPWD Texas Ecological System Classification (TES) polygons where canopy cover exists that could provide GCWA habitat. These potential habitat polygons were quantified to predict a variety of potential impact scenarios. To provide perspective, **Table 5-18** below summarizes potential habitat estimates for Diamond C and TES in relation to total acreages of the Land RSA and USFWS GCWA Recovery Region 6 (the GCWA RSA).

Table 5-18: Potential GCWA Habitat in US 281 Land RSA and GCWA RSA (USFWS Recovery Region 6)

GCWA Habitat Indicator	Land RSA (% of unit)	Region 6 (% of unit)
Diamond C Habitat Quality 4	68,119(19)	366,154 (14)
TPWD TES Vegetation Classes*	119,094 (38)	699,655 (26)
Total Acreage of Mapping Unit	356,547/313,157*	2,690,784

Source: TPWD and US 281 EIS Team, 2010
*Note that TPWD TES mapping is incomplete and only covers 313,157 acres of the 356,547-acre Land RSA. The portion not covered is south of Loop 1604 and primarily in developed portions of San Antonio.

As would be expected, the Diamond C (2007) model provides a more conservative estimate than the TPWD TES vegetation classes given its more focused construct. GCWA habitat models seek out specific vegetation patch size, landscape placement and other physical parameters associated with that species' requirements for survival. In contrast, the vegetation modeling efforts are more focused upon landscape and plant species specific reflectance values. Despite these limitations, their quantifications provide a relative, perspective of potential effects. As shown, the acreages of GCWA potential habitat in the Land RSA range from nearly 70,000 acres (19 percent) to nearly 120,000 acres (38 percent) for the Diamond C model and TPWD TES vegetation types, respectively. Roughly 14 percent of the USFWS GCWA Recovery Region 6 land area is considered potential medium to high quality (Level 4) GCWA habitat in the Diamond C model; about 26 percent of Region 6 is considered vegetation potentially useable by the GCWA in the TPWD TES classification system.

Table 5-19 summarizes areas classified as current development, direct project effects, indirect project effects, and cumulative effects areas containing vegetation that could potentially be GCWA habitat. The acreages shown for "indirect" and "other reasonably foreseeable" represent overlapping polygons of areas subject to potential development and areas predicted to contain GCWA habitat. They are useful for comparison purposes but should not be interpreted as directly equivalent to habitat impacts.

Table 5-19: Potential Cumulative Effects to Diamond (2007) Habitat & TPWD TES Vegetation Classes Potentially Suitable for GCWA Habitat (acres)

Build Alternative	Currently Developed	Direct	Indirect[1] (Project Effects as % of Cumulative Development)	Other Reasonably Foreseeable Future Development w/o Project[2]	Cumulative Development (as % of Total Potential Habitat in Land RSA)
Expressway Model C	4,075	0	5,057 (18%)	18,716	27,849 (41%)
Expressway TES	17,261	64	7,417 (14%)	27,789	52,531 (44%)
Elevated Expressway Model C	4,075	0	5,263 (19%)	18,716	28,055 (41%)
Elevated Expressway TES	17,261	55	7,668 (15%)	27,789	52,773 (44%)

[1] Represents total acreage of areas within which potential individual impacts may occur; encroachment-alteration effects were not deemed substantial and not quantified. Total acreage of surface disturbance of indirect impacts has not been quantified.
[2]Represents total acreage of areas within which potential reasonable foreseeable future impacts may occur even if US 281 project not constructed. Total acreage of surface disturbance from development activities has not been quantified.

The Land Use Panel involved in the indirect and cumulative impacts analysis indicated that, depending upon the Proposed Build Alternative, induced development could occur within in an area roughly 18,574 to 19,096 acres in size, a portion of which is composed of potential GCWA habitat. Total potential GCWA habitat cumulative acres were estimated by adding: currently developed area in potential GCWA habitat; direct project area in habitat; indirect effects area in habitat; and other reasonably foreseeable future development in habitat. Direct impacts to potential GCWA habitat range from zero to 64 acres, depending upon alternative, for Diamond Model C and TPWD TES vegetation classes, respectively. The Diamond model does not identify habitat directly affected by the proposed improvements. Currently, developed, potential impact areas range from 4,075 to 17,261 acres for Diamond Model C habitat and TPWD TES vegetation classes, respectively. Even without the proposed US 281 Corridor Project, estimates of reasonably foreseeable future development within potential GCWA habitat range from 18,716 (Diamond C) to 27,789 acres (TPWD TES). As shown in **Table 5-19**, the cumulative effects totals for potential GCWA habitat range from 27,849 acres to 28,055 acres for Diamond Model C and 52,531 acres to 52,773 acres for TPWD TES vegetation classes, depending upon alternative. In all cases, the Expressway Alternative has slightly fewer associated effects than the Elevated Expressway Alternative.

Cumulative effects scenarios such as described above are potentially substantial in a local context and range from 41 to 44 percent of potential GCWA habitat in the Land RSA. In the greater context of the GCWA RSA (USFWS GCWA Recovery Region 6), the relative effect is more diluted. The potential project-related development effects are estimated to contribute 14 percent to 19 percent of the total potential cumulative development effects to GCWA habitat within the Land RSA. These relative contributions vary primarily according to the habitat model used to make the estimates, and there are only slight differences in the estimates between the build alternatives, as shown in Table 5-19.

While not desirable, cumulative effects scenarios such as these are likely not surprising revelations to many local planning and conservation professionals who have expressed concern that habitat destruction enforcement and habitat conservation efforts have been somewhat overdue in the San Antonio area. In the RSA for the GCWA, this has been evidenced by the numerous habitat conservation planning efforts undertaken in the last decade, including the SEP HCP, EARIP, Comal County and Hays County HCPs, and other initiatives such as EDF Safe Harbor Agreements, and others. Some of these plans are summarized in **Section 4.2** of the Indirect Effects chapter. A summary of mitigation efforts is found later in this Cumulative Effects Analysis.

Black-capped Vireo

Since BCVI use mid-successional brushy habitat of fairly exacting characteristics (typically dense clumps separated by open or grassy ground with dense structure in the lowest 1-3 meters) in the Edwards Plateau ecoregion, it is inherently more difficult to identify from aerial photographs, much less model. In the area identified for potential induced development and other reasonably foreseeable future development effects, conditions are appropriate for some amount of BCVI habitat impacts; however, these would be impossible to quantify without field surveys. It is estimated that the RSA for the BCVI supports over 1,000 breeding males (Wilkins 2006). Further analysis through the SEP HCP process should provide more refined population estimates and mitigation plans to improve the prospects for this species continued viability in the RSA. Typically, these HCP efforts will identify, to the extent possible, known habitat and areas where BCVI habitat can be created and managed in perpetuity. These are typically large tracts over Edwards Formation limestones where appropriate vegetation and soils exist for mechanical habitat improvements and prescribed fire. Current models for such managed areas include the TPWD Kerr Wildlife Management area and, to a lesser extent, the TWPD Hill Country State Natural Area near Bandera.

5.7 STEP 7: REPORT THE RESULTS

This step of the cumulative impacts analysis presents a summary of the approach and findings of Steps 1-6 of the analysis.

The cumulative impacts analysis follows detailed guidance described at the beginning of this chapter from TxDOT, FWHA, CEQ, and applicable case law. The collection and analysis of information varied by resource or issue but generally were derived from current and historical reports, records, databases, and mapping.

5.7.1 Summary of Step 1: Identify Resources to Consider in the Analysis

This step involves determination of priorities based on potential adverse direct, and indirect, and vegetation types established by TES classification to the extent of the watershed boundaries of the Water Resources RSA effects impacts of the project and the relative health of or risk to each resource. Resource categories that were identified for evaluation of cumulative effects included:

- land resources
- socioeconomic and community resources
- air quality
- water resources – surface water
- water resources – groundwater
- ecological resources – vegetation and wildlife
- ecological resources – threatened and endangered species
- archeological resources
- historic resources

5.7.2 Summary of Step 2: Define the Study Area for Each Resource

The selection of a study area is influenced by the characteristics of each resource. RSA geographic descriptions are summarized in **Table 5-1**. RSAs were delineated for each of the resource categories, and except for several endangered species, the RSAs were portrayed on maps as follows:

- land resources – equivalent to the AOI (**Figure 5-1**)
- socioeconomic and community resources – equivalent to the Land RSA (**Figure 5-2**)
- water resources – surface water – boundaries of watersheds wholly or partially within Land RSA (**Figure 5-3**)
- water resources – groundwater – Edwards Aquifer contributing, recharge, transition and confined zones, and including portions of Trinity Aquifer- (**Figure 5-4**)
- ecological resources – vegetation and wildlife – vegetation types established by TES classification to the extent of the watershed boundaries of the Water Resources RSA – (**Figure 5-5**)
- ecological resources – threatened and endangered species – (**Figure 5-6** through **Figure 5-8**)

5.7.3 Summary of Step 3: Describe the Current Status/Viability and Historical Context for Each Resource

The intent of this step is to determine whether the sustainability of a resource is in decline or at risk, and what factors are useful indicators of potential positive or negative change in its condition. The current health and historical context of each resource is described in **Section 5.3** above. Most resource categories were determined to be stable or slightly declining due to continued development in the project Land RSA. Resources considered to be at more risk and requiring more focused evaluation were surface and groundwater quality and threatened and endangered species, especially the golden-cheeked warbler and its habitat.

5.7.4 Summary of Step 4: Identify Direct and Indirect Impacts of the Project that Might Contribute to a Cumulative Impact

In this step, the direct and indirect impacts of the Proposed Build Alternatives are summarized using information from **Chapter 3 - Affected Environment and Environmental Consequences** and **Chapter 4 - Indirect Effects**. The direct and indirect effects of the project are summarized for each of the Proposed Build Alternatives in **Table 5-5.**

5.7.5 Summary of Step 5: Identify Other Reasonably Foreseeable Future Effects

This step is based on information obtained from a variety of sources, principally the collaborative judgment of area planning and development professionals, who mapped their estimates of induced and other reasonably foreseeable future development in the Land RSA/AOI in 2035. To provide context and verification, an alternative set of population and residential development projections was developed through an analysis by SA Research Corporation (2010). This analysis provided control total verification based on Texas State Data Center and Census projections. The two forecasting approaches produced generally consistent results. Information from local planning and economic development officials, web sites of public agencies and other sources was used to compile lists of specific planned projects or programs may future development including transportation projects, private and public land development projects and infrastructure projects (are included in **Table 5-6** through **Table 5-10**)

5.7.6 Summary of Step 6: Identify and Assess Cumulative Impacts

Cumulative effects are defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions…" (40 CFR 1508.7). The cumulative effects evaluation focuses on the contextual relationships between the Proposed Build Alternatives' direct and indirect effects and the overall pattern of future development in the Land RSA, as estimated by the findings of the US 281 EIS Land Use Panel and the population/ residential absorption analysis (**Table 5-10**, **Figure 5-15**, **Figure 5-16**, and **Figure 5-17**). The expectations for cumulative effects described in the preceding resource assessments generally coincide with the projections of population growth in the Land RSA. Some of the affected resources are considered to be on a declining trend that is associated with the historic context of land settlement and accelerated population growth in the area.

Since the post-civil war settlement period there have been large-scale conversions of land throughout the study area, first from natural conditions to agricultural uses, especially livestock grazing, and then, in more recent decades, from rural communities and rangeland uses to suburban residential and associated commercial land uses. In the context of these historical changes and the resulting effects on resource conditions, the cumulative effects analysis considers the current status of resource conditions; the potential and probable cumulative effects of reasonably foreseeable land development on future resource conditions; and finally, the contribution to these cumulative effects that are represented by project-related direct and indirect effects.

In order to evaluate the magnitude of project-related development in the context of total cumulative development, it is useful to consider the percent that project-related development effects (direct plus indirect effects) comprise of the total cumulative development effects (past, present and reasonably foreseeable future development). This context has been noted in several of the previously presented resource discussions, for those effects analyses that lend themselves to acreage calculations. For example, for total land resources, which also reflects the total acreage of potentially-affected watersheds and the total acreage of potentially-affected vegetation and wildlife habitat in the Land RSA, the project-related development effects for either of the proposed Build alternatives is nine percent of the total cumulative development effects.

Likewise, we can calculate the proportional magnitude of project-related development effects for resources that occur in certain portions of or locations within Land RSA. For development on the Edwards Aquifer Recharge Zone, the project-related effects for both alternatives are one percent of the total cumulative development effects on the recharge zone in the Land RSA. Among the different waterbodies potentially affected by surface water quality changes that may be associated with the proposed project, the relative contribution of project-related development to total cumulative development expected in the Upper Guadalupe River drainage area is 32 percent. By comparison, the proportions of project-related to total cumulative development effects are two percent in the Canyon Lake drainage area, five percent in the Cibolo Creek drainage area, and 29 percent in the Dry Comal Creek drainage area.

For potentially-affected Golden-cheeked warbler habitat, the project-related effects range from 14 to 19 percent, depending on the habitat model considered, of the total cumulative development effects that are expected within potential GCWA habitat in the Land RSA. The elevated expressway alternative was found to be one percent higher than the expressway alternative in terms of the proportion that project-related effects make of the total estimated cumulative effects. For other wildlife habitat represented by the vegetation types in the Land RSA, the relative contribution of project-related development to the total cumulative development that may affect habitat is about 15 percent and 14 percent, respectively, for the oak-juniper uplands woods/forests vegetation type and the riparian woods and forests type.

A summary of cumulative effects of the proposed US 281 Corridor Project in combination with other non-related actions is presented by resource category on **Table 5-1** and described in the following sections.

Socioeconomic and Community Effects

The socioeconomic assessment of probable indirect and other reasonably foreseeable effects on the human populations concluded that there are no EJ populations or other vulnerable elements of the population within the Socioeconomics and Community RSA. **Appendix E** cited in **Section 5.3.2** concluded that members of minority or low income groups who will be users of the US 281 Corridor Project will not be adversely affected by the tolled or managed lanes options if those options are implemented as part of the project. The effects of induced growth and other reasonably foreseeable development in the RSA were evaluated with respect to the smaller communities and populated places in the currently less populated areas of the RSA. Most of these communities are diffused, with historical associations but less readily identifiable centers, community facilities, or other elements of cohesion. Many have been experiencing urban growth in their vicinity for a decade or more. Communities having more traditional urban structure and historic associations, like Fischer and Kendalia, are located at the far edge of the RSA, where little development is projected even in 2035.

Air Quality

The cumulative impact on air quality from the proposed US 281 Corridor Project and other reasonably foreseeable transportation projects are addressed at the regional level by analyzing the air quality impacts of transportation projects in *Mobility 2035,* 2011-2014 TIP, 2013-2016 TIP of the SA-BC MPO and the FY 2013-2016 STIP. The proposed project and the other reasonably foreseeable transportation projects were included in *Mobility 2035*, 2011-2014 TIP, and 2013-1016 TIP of the SA-BC MPO and the FY 2013-2016 STIP. Planned transportation improvements are intended to cumulatively reduce congestion on a regional scale, with a resultant decrease in pollutant emissions. Therefore, when combined, the proposed transportation improvements in the project area are anticipated to have a cumulatively beneficial impact on air quality.

Surface and Groundwater Resources

Surface Water

The direct, indirect, and other reasonably foreseeable future development effects associated with the US 281 Corridor Project will occur in the upper Guadalupe River, Canyon Lake, Cibolo Creek and Dry Comal Creek drainage areas, with other reasonable foreseeable future development and a substantial amount of past development affecting the Salado Creek and upper San Antonio River drainage areas. When the indirect effects of the project are added to other past, present, and reasonably foreseeable future actions, the extent of development in most of these drainage areas indicate a substantial potential for cumulative effects on water quality. Areas within which cumulative development is likely to occur cover about 17 percent of the Surface Water RSA and about 56 to 58 percent of the Land RSA. While precise locations, amounts, densities, and design characteristics of this future development cannot be ascertained at present, land use conversions to urban uses at this scale will lead to increases in impervious cover that has important influences on the hydrologic regime and water quality, as discussed in more detail in **Section 4.6.3.** The population densities that have been estimated for 2035 in the different parts of the RSA are indicative of the increased levels of impervious cover may be expected to accompany the project development. In the Cibolo Creek, Salado Creek, and the upper San Antonio River, and in parts of the drainage areas for the upper Guadalupe River and Canyon Lake, these population densities would be expected to result in future levels of impervious cover greater than 10 percent, which indicates probable substantive water quality effects to these water bodies and their tributaries.

Groundwater

The potential for groundwater quality effects related to cumulative land development within the Land RSA are summarized in **Table 5-13**. Although the Groundwater RSA extends over the entire southern segment of the Edwards Aquifer, the quantitative assessment of potential cumulative effects was limited to the portion of the aquifer within the Land RSA. These cumulative effects range from approximately 65,000 acres, depending on Build Alternative, in the contributing drainage area within the Land RSA, and 49,040 to 49,100 acres over the recharge zone. The project's induced development area includes 3,830 to 3,910 acres that lie upstream of the recharge zone that could affect Edwards Aquifer water quality and 610 to 690 acres of induced development over the recharge zone. These indirect development effects represent only five to six percent of cumulative development in the contributing drainage area, and approximately one percent of the aggregate cumulative development area over the recharge zone within the Land RSA. Considering its proportional contribution, the induced development component of cumulative effects to Edwards Aquifer water quality is not considered to be substantial, while the cumulative water quality effects to the aquifer from all past, present and future land development in the Land RSA are substantial.

Continued urban growth will bring more economic activity, mobility, and residential development to the project AOI. Cumulative effects associated with the project alternatives will also bring potentially substantial impacts to area resources, some of which may be at risk or in decline. Step 6 addressed potential impacts to socioeconomic and community resources, ecological resources, including vegetation, wildlife habitat, some federal-listed and state-listed endangered and threatened species; and water quality of surface and groundwater, air quality, and cultural resources. This step focuses on providing a context for understanding the contribution of the project's indirect effects to the overall cumulative effects of past, present, and reasonably foreseeable development in the area. The assessment concluded that the cumulative effects on GCWA habitat within the Land RSA are likely to be substantial with induced growth related to the proposed US 281 Corridor Project contributing a small but not inconsequential part. Substantial effects on surface water quality in the Upper Guadalupe River watershed were also identified, with the induced growth area are discussed in Indirect Effects playing a more prominent role.

Wildlife and Vegetation Effects

For both Proposed Build Alternatives, the area within which 2035 cumulative development is likely to occur covers more than 50 percent of the land area of the Land RSA. The Elevated Expressway Alternative (Non-toll, Toll and Managed Lanes) resulted in the highest amount of vegetated habitat potentially affected at 167,943 acres, with the Expressway Alternative (Non-toll, Toll and Managed Lanes) a close second at 167,451 acres. Even without the incremental effects of the projected US 281 Corridor Project-induced development (ranging from 18,574 acres to 19,096 acres), aggregate 2035 development (currently developed plus direct effects plus other reasonably foreseeable future development) within the Land RSA will be approximately 148,000 acres, which is approximately 47 percent of total RSA area of 313,158 acres. The actual amounts or locations of removal, modification or fragmentation of vegetation cannot be ascertained precisely, so these quantifications are useful mainly for comparison purposes. Nonetheless, the predicted amount of development and consequent effects on vegetation and wildlife habitat within the Land RSA is expected to be substantial.

Effects on Threatened and Endangered Species

The Cumulative Effects assessment addressed a number of federally- and state-listed species, including surface water aquatic species (mussels and Cagle's map turtle); aquifer species (invertebrates, salamanders and fish); terrestrial karst invertebrates; and birds (GCWA and BCVI). The *surface water aquatic species* within the affected parts of their RSAs are not considered to be critically at risk and probable substantial effects associated with future development are not expected. *Aquifer and spring species*, while critically dependent upon maintenance of variable flow at Comal and San Marcos Springs, are not substantially affected by the proposed project alternatives provided that the assumptions that long term water development projects and habitat protection programs like EARIP are successfully implemented. *Terrestrial karst invertebrates* were not identified in any of the known features along the proposed project ROW during the fall 2010 survey, and none of the currently listed species are known to occur in Comal County, where most of the induced and other reasonably foreseeable future development is expected to happen. It should be noted that areas for which right-of-entry was not granted at the time of survey were not investigated; therefore, determinations regarding species in these areas cannot be made at this time. Potential Bexar County habitat in Karst Zones 1 and 2 occurs within other reasonably foreseeable future development areas, therefore, it was determined that the effects to these potential karst features and their possible invertebrate inhabitants could be substantial.

Cumulative effects on the *golden-cheeked warbler* and GCWA habitat within the RSA could be substantial as a result of predicted development by 2035. GIS overlays of induced growth and other reasonably foreseeable future development areas on two GCWA habitat model maps resulted in estimated areas within which probable development could remove, fragment, or otherwise adversely affect warbler habitat. These estimated areas range from 26,137 acres to 52, 773 acres, depending on the Proposed Build Alternative and habitat model used (**Table 5-19**). This potential area of effect represents between 7.3 percent and 16.9 percent of the total Land RSA (356,547 acres); for comparison, the GCWA RSA (Region 6 of the Recovery Plan) covers over 2.6 million acres. Black-capped vireo habitat cannot be predicted accurately without field surveys, but habitat conditions exist that support an estimate that over 1,000 breeding males are supported within the RSA (Wilkins 2006). The availability of existing and possible future areas of habitat managed areas through the SEP HCP and other programs reduce the concern that the BCVI would be substantially affected by cumulative development associated with the proposed US 281 Corridor Project.

Effects on Cultural Resources

Archeological Resources

No archeological sites were identified during surveys of the designated APE. As a result, effects to archeological resources are not considered to be substantial. Nonetheless, site probability analysis found that numerous prehistoric and historic archeological sites are likely to exist within the Archeological RSA. Many of these undocumented and regulatory-unprotected sites are likely to be affected by cumulative development predicted to occur within the Archeological RSA, though these effects cannot be calculated.

Historic Resources
No potentially NRHP-eligible sites were identified during historic resource surveys of the designated APE; therefore, effects to historic resources are not considered to be substantial. The likely presence of numerous historic-aged resources within the Historic RSA is noted, though, and many of these undocumented and regulatory-unprotected sites are likely to be affected by cumulative development expected to occur within the Historic RSA.

5.8 STEP 8: ASSESS THE NEED FOR MITIGATION

This section discusses federal, state, and local governmental regulations and programs, and other initiatives that currently exist to protect the resources examined with regard to cumulative effects. Because regulatory compliance per se is not considered to be a part of mitigation, additional mitigation measures that could greatly reduce adverse effects to resources are presented and discussed.

5.8.1 Regulatory Resource Protective Measures

Federal Regulations

Air Quality
The Federal Clean Air Act (CAA) of 1970 authorized the development of comprehensive federal and state regulations to limit emissions from both stationary (industrial) sources and mobile sources. Four major regulatory programs were initiated: the National Ambient Air Quality Standards (NAAQS), State Implementation Plans (SIP), New Source Performance Standards (NSPS), and National Emission Standards for Hazardous Air Pollutants (NESHAPs).

The CAA required areas to create plans to meet the air quality standards and set deadlines for achieving those standards. Using this authority, the Environmental Protection Agency (EPA) set air quality standards for six air pollutants:

- sulfur dioxide (SO_2)
- particulate matter (PM)
- nitrogen dioxide (NO_2)
- carbon monoxide (CO)
- ozone (O_3)
- lead (Pb)

Revisions to the Ozone Standard
In April 2004, the EPA published revisions to the air quality standards (as shown in **Table 5-20**). A key modification to the O_3 standard was a change in averaging time, thus strengthening the standard. Formerly, measurements of O_3 were averaged over a one-hour block of time, but the new requirement increased the time to an eight-hour period. Due to these stricter standards more areas throughout the nation were labeled nonattainment. The EPA is required to revisit the air quality standards every five years and set new standards if deemed necessary to protect public health with "an adequate margin of safety". In March 2008, the Environmental Protection Agency significantly strengthened the air quality standards again, by lowering the ozone standard from 85 parts per billion (ppb) to 75 ppb. These changes will again increase the number of areas

to receive non-attainment status, but at the same time improve both public health and the protection of sensitive trees and plants.

Table 5-20: National Ambient Air Quality Standards

Pollutant [final rule cite]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide [76 FR 54294, Aug 31, 2011]		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead [73 FR 66964, Nov 12, 2008]		primary and secondary	Rolling 3 month	0.15 μg/m3 (1)	Not to be exceeded
Nitrogen Dioxide [75 FR 6474, Feb 9, 2010] [61 FR 52852, Oct 8, 1996]		primary	1-hour	100 ppb	98th percentile, averaged over 3 years
		primary and secondary	Annual	53 ppb (2)	Annual Mean
Ozone [73 FR 16436, Mar 27, 2008]		primary and secondary	8-hour	0.75 ppm (3)	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particulate Matter [71 FR 61144, Oct 17, 2006]	**$PM_{2.5}$**	primary and secondary	Annual	15 μg/m³	Annual mean, averaged over 3 years
			24-hour	35 μg/m³	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 μg/m³	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide [75 FR 35520, Jun 22, 2010] [38 FR 25678, Sept 14, 1973]		primary	1-hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Source: EPA as of October 2011 (http://www.epa.gov/air/criteria.html)
(1) Final rule signed October 15, 2008. The 1978 lead standard (1.5 μg/m3 as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.
(2) The official level of the annual NO2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.
(3) Final rule signed March 12, 2008. The 1997 ozone standard (0.08 ppm, annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years) and related implementation rules remain in place. In 1997, EPA revoked the 1-hour ozone standard (0.12 ppm, not to be exceeded more than once per year) in all areas, although some areas have continued obligations under that standard ("anti-backsliding"). The 1-hour ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than or equal to 1.
(4) Final rule signed June 2, 2010. The 1971 annual and 24-hour SO2 standards were revoked in that same rulemaking. However, these standards remain in effect until one year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

Waters of the United States

Impacts to waters of the U.S. are regulated under provisions of Section 404 of the Clean Water Act. Waters of the U.S. include rivers, streams (including perennial, intermittent, and ephemeral), bogs, sloughs, lakes, reservoirs, ponds (including stock tanks connected to other jurisdictional waters), and wetlands. The jurisdictional area of lakes, ponds, rivers, and streams are identified as that portion below the ordinary high water mark (OHWM). The OHWM is defined as:

> ***"…that line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed in the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas (33 CFR 328.3)."***

Wetlands, as defined by the USACE and U.S. Environmental Protection Agency, are those "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions". National Wetland Inventory maps indicate that there are 9,697 acres of wetlands or waters of the U.S within the Land RSA (USFWS 1994, 1999). Removing the development-restricted acreage (e.g.,Canyon Lake, 100-year floodplains) leaves about 545 wetlands , including non-jurisdictional off-channel ponds. Of this total, about 78 acres are considered likely to be developed by 2035, including 27 acres in the induced development area of the US 281 Corridor Project. A field investigation to determine if wetlands are present has not been conducted within the AOI or water resources RSA, but such an investigation would be required for addressing direct impacts of any public or private project. Any discharge of fill into such waters requires a permit issued by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act.

Water Quality

Pursuant to the Clean Water Act, the Environmental Protection Agency (EPA) has established water quality standards that protect beneficial uses of waterbodies. The overriding performance standard for water quality adopted by the states is that they maintain and protect the physical, chemical and biological integrity of the nation's waters. Establishment and enforcement of water quality standards in the State of Texas has been delegated to the Texas Commission on Environmental Quality (TCEQ).

Endangered Species

Impacts to federally-listed endangered or threatened species are regulated under provisions of the Endangered Species Act. The Act is administered and enforced by the U.S. Fish and Wildlife Service (USFWS). Impacts may include adverse modification or alteration of habitat. Several threatened and endangered species are dependent on either, water resources, woodland habitat or karst habitat within the AOI. Such impacts may include adverse modification or alteration of habitat. Section 7a of the Endangered Species Act establishes procedures for consultation between the USFWS and federal agencies, who must ensure that any actions that they fund, authorize, permit or otherwise carry out will not jeopardize the continued existence of any listed species or adversely modify designated critical habitats.

Wildlife, Including Migratory Birds

Impacts to migratory birds and their active nests (including adult birds, eggs and young) are generally prohibited and are regulated under provisions of the Migratory Bird Treaty Act as enforced by the USFWS. Ponds, reservoirs, streams and rivers and many terrestrial habitats within the AOI provide habitat for many different kinds of migratory birds.

State Regulations

State Lands

Development projects that will involve potential impacts to state lands administered by the Texas General Land Office (GLO) may require easements or other property use agreements.

Impacts of Public Utilities

The Texas Public Utilities Commission (PUC) grants Certificates of Convenience and Necessity (CCN) for Utility projects in Texas and may require specific provisions in the issuance of a CCN for the protection of specific environmental and cultural resources.

Air Quality

The TCEQ regulates air emissions to comply with the Federal Air Quality Standards. The agency also issues permits for air emissions. As required for areas that are designated in nonattainment of federal air quality standards, a State Implementation Plan (SIP) is an enforceable plan developed at the state level that explains how the state will comply with air quality standards according to the Federal Clean Air Act. SIPs may be superseded by federal implementation plans if necessary.

Surface Water Quality

In compliance with Sections 305(b) and 303(d) of the Federal Clean Water Act (CWA), the TCEQ evaluates water bodies in the state and identifies those that do not meet uses and criteria defined in the Texas Surface Water Quality Standards (TSWQS). TSWQS establish explicit goals for the quality of streams, lakes, and bays throughout the state. The standards are promulgated in Title 30, Chapter 307, of the Texas Administrative Code. The TSWQS are considered in federal and state wastewater discharge permitting programs, and are subject to approval by the EPA. TSWQS identify appropriate uses for the state's surface waters, including aquatic life, contact or non-contact recreation, and source of public water supply. The statewide water quality assessment evaluates common indicators of water quality, such as dissolved oxygen (DO), temperature, pH, dissolved minerals, toxic substances, and bacteria, as well as the status of biological communities such as fish and macroinvertebrates.

The biennial statewide water quality inventory includes the generation of a Clean Water Act Section 303(d) – List of impaired water bodies. The 303(d) List identifies and prioritizes a list of water bodies that do not comply with the TSWQS, and specifically it lists those for which effluent standards alone are not considered sufficient to achieve the criteria in the TSWQS, also known as water quality-limited segments. This inventory prioritizes waters for additional work by the TCEQ, and by the Texas State Soil and Water Conservation Board in rural land use areas, to determine a total maximum daily load (TMDL) of a given pollutant that can be assimilated, and to document and evaluate conditions in order to restore water quality in a given water body.

The TCEQ also administers the Edwards Aquifer Protection Program rules for protection of the Edwards Aquifer from development over the contributing, recharge, and transition zones. The TCEQ does not allow wastewater discharge into streams and rivers contributing to the Edwards Aquifer Recharge Zone. The EAA has also established rules for protection of groundwater quality involving the regulation of underground storage tanks and the construction, operation, maintenance, abandonment, and closure of wells.

The TCEQ has regulatory authority that applies to development over the Edward Aquifer contributing, recharge, and transition zones and has developed rules for protection of the aquifer within these zones.

Water Appropriation and Use

The appropriation and use of surface water and groundwater is administered by fundamentally different law as guided and interpreted by initial statues established by the Texas Legislature and refined through subsequent court rulings.

Ownership of surface water is asserted by the state of Texas and includes the "ordinary flow, underflow, and tides of every flowing river, natural stream, and lake, and of every bay or arm of the Gulf of Mexico, and the storm water, flood water, and rainwater of every river, natural stream, canyon, ravine, depression, and watershed in the state" (Texas Water Code, §11.021(a)). The code however, does allow "use" of water to the extent that a water user has been granted rights to the water. A person desiring to appropriate water may obtain a water use permit under §§ 11.124 -11.136, if he can show that a) un-appropriated water is available in the source of supply; b) the proposed appropriation contemplates application of water to a beneficial use; c) the proposed appropriation does not impair existing water rights or vested riparian rights; d) the proposed appropriation is not detrimental to the public welfare; and e) reasonable diligence will be used to avoid waste and achieve conservation.

While the property rights in groundwater are less clear, the Texas common law *Rule of Capture* provides that the surface estate owner has the right to pump groundwater from beneath the surface of his or her estate and that one cannot sue his or her neighbor for injunctive relief or damages resulting from the neighbor's depletion of the groundwater with the exceptions of malice, land subsidence, and waste.

Groundwater Management

According to the Texas Water Code § 35.001, groundwater management areas may be created "in order to provide for the conservation, preservation, protection, recharging, and prevention of waste of the groundwater, and of groundwater reservoirs or their subdivision, and to control subsidence caused by withdrawal of water from those groundwater reservoirs or their subdivision, consistent with the objectives of Section 59, Article XVI of the Texas Constitution….". Portions of two groundwater management areas (GMA 9 & 10) occur within the AOI. GMAs were created to provide for the conservation, preservation, protection, recharging, and prevention of waste of the groundwater, and of groundwater reservoirs or their subdivisions, and to control subsidence caused by withdrawal of water from those groundwater reservoirs or their subdivisions, consistent with the objectives of Section 59, Article XVI, Texas Constitution (Texas Water Code § 35.001). In addition, portions of four Groundwater Conservation Districts (GCDs) occur within the AOI. These include: the Trinity-Glenrose GCD in northern Bexar County; Cow Creek GCD in Kendall County; Blanco-Pedernales GCD in

Blanco County; and Hays-Trinity GCD in Hays County. The GCDs are required by state law to develop and implement a management plan for the effective management of their groundwater resources. The TWDB is the agency charged with the approval of groundwater management plans. Virtually all of the GCDs have approved plans or have submitted plans in the process of being approved.

The EAA was created in 1993 to manage groundwater withdrawals throughout most of the San Antonio segment of the Edwards Aquifer and limit the amount of groundwater withdrawn under the Rule of Capture. Mandated responsibilities by the Authority are broader than those of the individual Groundwater Conservation Districts that occur within its regulatory boundary.

The TCEQ has been delegated responsibility by the EPA to enforce federal water quality standards. This includes regulation of stormwater discharges under the General Construction Permit and Municipal Separate Storm Sewer Systems (MS4) permitting programs.

Fish and Wildlife

The TPWD administers regulations for the protection of game species, non-game species, and state-listed endangered and threatened species. The TPWD also issues permits for development projects that would impact the streambeds of state-designated streams or rivers and manages mitigation land required to satisfy regulatory compliance of several surface reservoirs in Texas. The agency also administers the state's parks, natural areas, and specific historic sites. The Texas Parks and Wildlife Code (Chapter 64, Subchapter A, Sections §64.002 and §64.003) provides a state law that prohibits the disturbance or destruction of the eggs, nest, or young of a bird that is a wild game bird, a wild bird, or a wild fowl, except that this prohibition does not apply to the non-native birds European starlings, English sparrows, and feral rock doves.

Local Regulations

The City of San Antonio has designated the SAWS as its enforcement agent for protection of the Edwards Aquifer and for watershed management over the Edwards Aquifer Recharge Zone. The provisions of the City of San Antonio's Aquifer Protection Program (City Code Chapter 34, Article VI Pollution Prevention and Control, Division 6 Aquifer Recharge Zone and Watershed Protection) apply to SAWS' roles in protection of the Edwards Aquifer and in watershed management over the Edwards Aquifer Recharge Zone. SAWS will review proposed subdivision plats according to the requirements of the Aquifer Protection Ordinance No. 81491. The ordinance provides for floodplain preservation and floodplain buffer zones, recharge feature protection and buffer zones, impervious cover limits applicable to the City Limits and also within the extra-territorial jurisdiction (ETJ) over the Edwards Aquifer Recharge Zone, and stormwater detention, sedimentation and filtration requirements for multi-family and commercial developments. Impervious cover limits for single family residential developments are a maximum of 30 percent gross impervious cover within the city limits, and 15 percent gross impervious cover within the ETJ when over the Edwards Aquifer Recharge Zone. Limits for commercial development are a maximum of 65 percent gross impervious cover within the city limits, and 15 percent gross impervious cover within the ETJ when over the Edwards Aquifer Recharge Zone. The EAA has considered adoption and implementation of impervious cover rules during 2010 and

2011 that would apply within its jurisdiction, according to its Strategic Plan (EAA 2010). No action has been taken on these rules as of April 2012.

The porous, permeable limestone in the AOI provides no storage or natural treatment of wastewater or stormwater, creating the potential for polluted runoff to flow into streams, rivers, and recharge features. Texas law requires that wastewater systems over the Edwards aquifer recharge zone be tested every five years. All lines over 6 inches must be tested. Currently, there are 56 miles of sewer mains and 1,000 manholes in the SAWS wastewater system over the Edwards aquifer recharge zone, which SAWS must monitor and test.

5.8.2 Other Resource Conservation and Mitigation Programs

Mitigation of environmental impacts covers an array of actions that should be considered in the following sequence: (1) avoiding impacts to the maximum extent possible; (2) minimizing impacts; and (3) compensating for any impacts after avoidance and/or minimization measures have been incorporated. Compensatory mitigation can be further defined as the restoration, creation, enhancement, or preservation of resources to offset unavoidable impacts after avoidance and minimization measures have been employed. A number of governmental and non-governmental programs, policies, and activities are currently on-going that will potentially mitigate effects of the proposed project as well as other projects on the major resource categories included in the cumulative effects analysis. Programs and activities that have measures designed to avoid, minimize, or compensate for impacts to particular resource categories are summarized below in **Table 5-21.** These actions have been subdivided into several major categories:

- specific programs and projects
- federal, state, and local regulations, policies, and programmatic measures
- strategic and comprehensive plans prepared by regional governmental entities
- recent/current litigation with implications for natural resources

Table 5-21: Resource Conservation/Protection and Mitigation Programs Related to Potential Cumulative Impacts of Proposed US 281 Corridor Project from Loop 1604 to Borgfeld Drive

#	Target Resource	Program/Project Name and Description	Development/ Planning Entity
A. Specific Programs and Projects			
1	Water Resources: Edwards Aquifer	Edwards Aquifer Recharge Initiative -Type 1 and Type 2 Projects- Edwards Aquifer recharge enhancement from upstream runoff detention (Type 1) and temporary channel impoundments (Type 2). http://www.edwardsaquifer.org/ http://www.edwardsaquifer.org/pdfs/Reports/AS%20Reports/Recharge%20Enhancement%20Studies/R%20and%20R%20Phase%20I%20%20Rpt%20-%20PDF.pdf	SAWS, with Guadalupe Blanco River Authority (GBRA), San Antonio River Authority (SARA), EAA, & US Army Corps of Engineers (USACE) Nueces River Authority, City of Corpus Christi also for Nueces Basin
2	Ecological Resources: Endangered Species Dependent on the Edwards Aquifer	Edwards Aquifer Recovery Implementation Program (EARIP) Regional Habitat Conservation Plan (HCP) – Development of a regional HCP for approval by the USFWS and subsequent issuance of a Section 10(a)1(B) Incidental Take Permit for Endangered species dependent on the Edwards Aquifer. http://earip.tamu.edu/	EAA, SAWS, GBRA, SARA, Nueces River Authority, multiple counties and municipalities
3	Ecological Resources: Endangered Species	Comal County Regional HCP- Plan for voluntary participation by county, municipalities and private landowners to preserve habitat for golden-cheeked warbler and black-capped vireo. http://www.co.comal.tx.us/comalrhcp/default.htm	Comal County Commissioner's Court
4	Ecological Resources: (1) Endangered Bird Species (2) Karst Invertebrates	Southern Edwards Plateau Regional Habitat Conservation Plan- Plan for voluntary participation by private landowners to preserve habitat for golden-cheeked warbler and black-capped vireo, and Karst Invertebrates. http://www.sephcp.com/	COSA, Bexar County and likely other entities (goal is to bring in Bandera, Comal, Kendall, Kerr, Blanco & Medina Co's)
5	Ecological Resources: (1) Endangered Species (2) Karst Invertebrates	Project Specific HCPs, Management and Recovery Plans – E.g., Camp Bullis Karst Species Management Plan; Government Canyon State Natural Area Karst Mgmt & Recovery Plan; La Cantera HCP; TCMA Robber Baron Mgmt Plan; Conservation/mgmt commitments related to either §7 Consultations (Camp Bullis) or individual 10(a) permits with USFWS. http://www.nature.org/wherewework/northamerica/states/texas/ http://www.fws.gov/endangered/species/recovery-plans.html	USDOD, TX Nature Conservancy, TPWD, Private Developers

Table 5-21: Resource Conservation/Protection and Mitigation Programs Related to Potential Cumulative Impacts of Proposed US 281 Corridor Project from Loop 1604 to Borgfeld Drive

#	Target Resource	Program/Project Name and Description	Development/ Planning Entity
6	Ecological Resources: Endangered Species	Landowner Conservation Assistance & Safe Harbor Programs GCWA based exclusively in 20 counties primarily in Edwards Plateau; est. 9,000 pairs (Ft. Hood with 4,000) plus 2,000 in Balcones Canyonlands Wildlife Refuge (BCWR). EDF program addresses private land, seeks to steadily improve relationships with landowners. Ref BCCP (HCP); BCNWR; Ft. Hood (10x increase). EDF has enrolled 80 Central Texas landowners covering about 120,000 ac of ranch land (Wolfe 2010).	Environmental Defense Fund (EDF)
7	Ecological Resources: Endangered Species	Ft Hood Recovery Credit System (RCS) Fort Hood invests funds in conservation actions designed to benefit the GCWA on private lands. In return, Fort Hood receives credits that it uses as needed to offset actions on the base that may adversely affect the warbler and its habitat. http://www.fws.gov/home/feature/2007/endangeredspeciesrecoveryqsandasvf1107.pdf http://www.edf.org/article.cfm?contentID=6527 http://www.affoundation.org/rcs-summary-9-08.pdf	Fort Hood – Dept of Defense (DOD), USFWS,
8	Ecological Resources: Endangered Species	2009 USFWS Biological Opinion for Vegetation Thinning on Camp Bullis Protection Established a 3,000 acre preserve at TPWD Government Canyon State Natural Area (SNA) with agreement giving US Army 1100 mitigation credits to allow thinning of 762 ac (under Army Compatible Use Buffer [ACUB] funding) Cannizo (2010).	US Army Camp Bullis City of San Antonio (COSA) TPWD
9	Ecological Resources: Endangered Species	Species Conservation Banking – e.g., Hickory Pass Ranch mitigation credits were established for an endangered species (GCWA) for sale to developers, local governments, TxDOT, or other entities to offset impacts on other locations. Hickory Pass Ranch in central Texas developed habitat enhancement measures for GCWA to obtain one credit for each acre of managed land with each credit priced at $5,000. http://www.forest-trends.org/documents/files/doc_603.pdf (Glen 2010)	USFWS – private interests

Table 5-21: Resource Conservation/Protection and Mitigation Programs Related to Potential Cumulative Impacts of Proposed US 281 Corridor Project from Loop 1604 to Borgfeld Drive

#	Target Resource	Program/Project Name and Description	Development/ Planning Entity
10	Ecological Resources: 1) Veg/Wildlife Habitat 2) Endangered Species 3) Karst Invertebrates	Sensitive Land Acquisition Program -- Water Supply Fee-funded program for protection of geologically sensitive areas, point recharge features, using Conservation Easements and Fee Simple land acquisitions; 9,140 acres preserved at Government Canyon SNA, Davis Ranch, Stone Oak Park, Annandale Ranch. http://www.saws.org/our_water/ResourceProtComp/Aquifer_Protection/aquisition.shtml	SAWS in Partnership with Nature Conservancy, Trust for Public Land, Bexar Land Trust, Texas Cave Management Association
11	Water Resources	Recreation Management on Comal River – Organization to protect river and promote more environmentally sensitive behavior among recreational users. http://www.wordcc.com	Water Oriented Recreation District (WORD) of Comal County
B. Federal, State, and Local Regulations, Policies, and Programmatic Measures			
1	Water Resources: Edwards Aquifer	EAA Proposed Rules to Limit Impervious Cover – Regulations to be developed, implemented and enforced to protect water quality of the Edwards Aquifer by establishing a limit of the development of impervious cover over the recharge zone. http://www.edwardsaquifer.net/news.html http://www.edwardsaquifer.net/news.html	EAA
2	Water Resources: Edwards Aquifer	Edwards Aquifer Protection Program -- Development review and regulation over the EA Recharge and Contributing Zones; wellhead protection program, abandoned well program http://www.saws.org/our_water/ResourceProtComp/groundwater_protection/wellhead/	SAWS
3	Water Resources: Edwards Aquifer	Edwards Aquifer Rules and Protection Program – Includes permitting and incorporation of Best Management Practices: Rules affect development over the Edwards Aquifer, Contributing, Recharge and Transition Zones. http://www.tceq.state.tx.us/compliance/field_ops/eapp/program.html	TCEQ
4	Water Resources: Water Quality	Edwards Aquifer Protection Program – An initiative currently implemented by the City of San Antonio to protect the aquifer by acquiring sensitive and irreplaceable land located over its recharge and contributing zones. Funding is provided by Proposition 3 (2000) and Proposition 1 (2005). . Over 54,000 acres have been acquired and protectedhttp://www.sanantonio.gov/edwards/background.asp?res=1024&ver=true	City of San Antonio

Table 5-21: Resource Conservation/Protection and Mitigation Programs Related to Potential Cumulative Impacts of Proposed US 281 Corridor Project from Loop 1604 to Borgfeld Drive

#	Target Resource	Program/Project Name and Description	Development/ Planning Entity
5	Water Resources Ecological Resources: 1) Waters of US/ wetlands 2) Endangered Species	USACE Sec. 404 ESA Sec. 7(c)(1) Agencies to carry out conservation programs for benefit of T&E spp, usually as part of Biological Opinion. May be discretionary, under "Conservation Recommendations" to minimize or avoid. Becomes responsibility of action agency. http://www.swf.usace.army.mil/pubdata/environ/regulatory/index.asp	USACE/ USFWS
6	Water Resources: Groundwater Ecological Resources: Wildlife Habitat	Environmental Quality Incentives Program (EQUIP) Rural Land – Urban Water Program manages land to boost water supply (e.g., Round Mtn. – Reagor Ranch). In partnership w/NRCS landowners clear cedar, plant native grasses, restore open space. "Rural land–Urban Water" (NRCS pgm). Cuts allergens. http://www.nrcs.usda.gov/programs/eqip/	NRCS
7	Water Resources Ecological Resources: Wildlife Habitat	Sec. 404(b)Guidelines–requires agency to determine potential short & long term effects by determining nature and degree of effect the proposed discharge will have, individually & cumulatively. http://www.wetlands.com/regs/tlpge03g.htm	USACE EPA
8	Ecological Resources: Veg/Wildlife Habitat Water Resources: 1) Water Quantity 2) Water Quality	Partners in Wildlife - Federal subsidies for erosion control and water quality, quantity and grazing improvements. http://www.fws.gov/partners/strategicPlan.html	USDA NRCS
9	Ecological Resources: 1) Vegetation 2) Wildlife Habitat Water Resources: 1) Water Quantity 2) Water Quality	FHWA Mitigation Policy - guidance establishing minimum conditions and requirements for Federal-aid funding of ecological mitigation, including development of ecological mitigation banks. http://www.fhwa.dot.gov/legsregs/directives/policy/memo48.htm	Federal Highway Administration (FHWA)

Table 5-21: Resource Conservation/Protection and Mitigation Programs Related to Potential Cumulative Impacts of Proposed US 281 Corridor Project from Loop 1604 to Borgfeld Drive

#	Target Resource	Program/Project Name and Description	Development/ Planning Entity
10	Ecological Resources: 1) Vegetation 2) Wildlife Habitat Water Resources: 1) Water Quantity 2) Water Quality	Landscape Conservation Cooperatives - Landscape Conservation Cooperatives focus on-the-ground strategic conservation efforts at the landscape level. LCCs are management-science partnerships that inform integrated resource-management actions addressing climate change and other stressors within and across landscapes. They will link science and conservation delivery. http://www.doi.gov/whatwedo/climate/strategy/LCC-Map.cfm http://elips.doi.gov/app_so/act_getfiles.cfm?order_number=3289A1	U.S. Dept of the Interior (USDI)
11	Ecological Resources: 1) Vegetation 2) Wildlife Habitat Water Resources: 1) Water Quantity 2) Water Quality	Property Tax Incentives (Ag and Wildlife Exemptions)- Programs which lower taxes on lands managed for agriculture or wildlife production http://www.noble.org/ag/Wildlife/TaxExempt/index.html http://www.tpwd.state.tx.us/landwater/land/private/agricultural_land/	County Appraisal Districts – often in conjunction with TPWD biologists (assist with mgmt plans)
12	Ecological Resources: Veg/Wildlife Habitat Water Resources: Water Quantity Water Quality	NRCS Conservation Reserve Program & Brush Control Programs – Federal subsidies for erosion control and water quality, quantity and grazing improvements. http://www.nrcs.usda.gov/programs/crp/	USDA NRCS
13	Ecological Resources: 1) Vegetation 2) Wildlife Habitat	City of San Antonio Tree Preservation Ordinance in environmentally sensitive areas http://www.sanantonio.gov/dsd/treelanscape_team.asp?res=1024&ver=true	COSA/Planning & Development Services
14	Ecological Resources: 1) Vegetation 2) Wildlife Habitat Water Resources: 1) Water Quantity 2) Water Quality	Environmental Defense Fund Private Landowner Projects – Program which offers incentives for conservation (often uses Safe Harbor Agreements). http://www.edf.org/home.cfm http://www.edf.org/page.cfm?tagID=52 E.O. 13112	Environmental Defense Fund and USFWS

Table 5-21: Resource Conservation/Protection and Mitigation Programs Related to Potential Cumulative Impacts of Proposed US 281 Corridor Project from Loop 1604 to Borgfeld Drive

#	Target Resource	Program/Project Name and Description	Development/ Planning Entity
15	Ecological Resources: 1) Vegetation 2) Wildlife Habitat	Programs to acquire sensitive or threatened landscapes often using inheritance tax or other financial incentives. http://www.nature.org/wherewework/northamerica/states/texas/ http://www.tpl.org/ http://greenspacesalliance	Texas Nature Conservancy, Trust for Public Lands, Bexar Land Trust, Green Spaces Alliance of South Texas, other NGO and private land trusts
16	Ecological Resources: 1) Endangered Bird Species 2) Karst Invertebrates	Species Specific Recovery Plans - Recovery goals established in GCWA, BCVI and Karst Invertebrate Recovery Plans (for example). http://www.fws.gov/endangered/species/recovery-plans.html	USFWS
17	Ecological Resources: Endangered Species	Safe Harbor Program - Endangered species habitat restoration projects usually on private lands to both assist species and protect landowners from future exposure to non-compliance. http://www.fws.gov/endangered/landowners/safe-harbor-agreements.html	USFWS
18	Ecological Resources: Endangered Species	State listing of freshwater mussels and potential Federal listing TPWD has listed 15 spp as State T&E. USFWS has issued a 90 day finding on a petition to list 9 spp – ruled there is sufficient information to possibly warrant listing, has begun 12 month listing review process. "Proposed for listing" means 404 permits and 401 certification must consider these spp as they may be listed in the future as endangered, threatened, or candidates. http://www.tpwd.state.tx.us/huntwild/wild/species/endang/regulations/us/index.phtml	TPWD USFWS
19	Ecological Resources: Endangered Species	Candidate Conservation Agreements with Assurances (CCAAs)Program Conservation agreements can be established for species in anticipation that they may be listed as endangered or threatened in the future and can address mitigation requirements in advance of listing and incorporate "no surprises" assurance. Policies are still in development http://library.fws.gov/Pubs9/cca01.pdf	USFWS and potential Developers

Table 5-21: Resource Conservation/Protection and Mitigation Programs Related to Potential Cumulative Impacts of Proposed US 281 Corridor Project from Loop 1604 to Borgfeld Drive

#	Target Resource	Program/Project Name and Description	Development/ Planning Entity
20	Historic & Archeological Resources	Cultural Resource Surveys as Required by Texas Antiquities Code and NHPA. Could result in a requirement to prepare an evaluation of eligibility for NRHP and subsequent nomination; future avoidance, where possible, or minimization/mitigation of harm to significant cultural resources; development of state historic markers; additional research and development of educational material. http://www.tbpe.state.tx.us/nm/acot.htm http://www.nps.gov/history/local-law/nhpa1966.htm	Texas Historical Commission FHWA
21	Air Resources	Air Quality Early Action Plan to prevent Non-Attainment Status - Public-private partnerships for voluntary actions. http://www.sanantonio.gov/oep/airquality.asp?res=1280&ver=true	Alamo Area COG, Air Improvement Resources Committee (AIRCO)
22	Land Resources: Farmland	Farmland Protection Policy Act Requires direct and indirect assessments. http://www.nrcs.usda.gov/programs/fppa/	NRCS
23	Land Resources: Farmland	Farmland Effects Assessment - Requires assessment of direct and indirect environmental effects of any loss of productivity of agricultural land. http://www.environment.fhwa.dot.gov/projdev/impta6640.asp	FHWA
24	Groundwater Resources Ecological Resources: 1) Vegetation 2) Wildlife Habitat	Research Studies on rangeland restoration and brush management and control - Studies that document economic benefits of additional yield of groundwater from control of specific rangeland restoration practices in Edwards Plateau and South Texas Plains.	Various academic and research institutions
C. Strategic and Comprehensive Plans Prepared by Regional Governmental Entities			
1	Land Resources Historic/ Archeological Resources	Bulverde Comprehensive Plan: Sunrise 2025 - The comprehensive plan addresses critical issues in development that apply to most small towns with an expected population influx; therefore, the plan serves as an example for other small town urbanization that will occur as a result of US 281 improvements and subsequent development.	City of Bulverde

Table 5-21: Resource Conservation/Protection and Mitigation Programs Related to Potential Cumulative Impacts of Proposed US 281 Corridor Project from Loop 1604 to Borgfeld Drive

#	Target Resource	Program/Project Name and Description	Development/ Planning Entity
2	Land Resources Ecological Resources: Endangered Species Water Resources	Camp Bullis Joint Land Use Study (Draft) - offers recommendations regarding avoidance of the consequences of incompatible development of the Camp Bullis military installation and the surrounding areas. It stresses the interdependency of the installation and the community and attempts to facilitate joint planning to protect the military mission as well as the health of the economies and industries of the community. By addressing compatibility/encroachment issues, the JLUS aims to protect residents' quality of life, property owners' rights, and the existing and future mission of the installation. http://www.campbullisjlus.com/	City of San Antonio with Funding by Dept of Defense
3	Water Resources: 1) Edwards Aquifer 2) Water Quality 3) Endangered Species	Edwards Aquifer Authority Strategic Plan 2010-2012 – lays out direction for 1) sustaining federally protected, aquifer-dependent species through development of a Recovery Implementation Program (resulting in a HCP), (2) management of groundwater withdrawals, and (3) development of a recharge program for improved aquifer management and environmental restoration. In terms of water quality, the EAA plans to implement and expand protection initiatives, benefiting the economy and species dependant on the aquifer. http://www.edwardsaquifer.org/files/REV_Final%202010-2012_Strategic_Plan_approved101309.pdf	EAA
4	All Resource Categories	Mobility 2030: San Antonio-Bexar County Metropolitan Transportation Plan - Analyzes what will happen in the next 25 years if current trends continue, and proposes actions to be implemented in order to relieve congestion, maintain air quality, and improve quality of life; assists in guiding transportation project decisions. Transportation Improvement Program (TIP). http://www.sametroplan.org/Plans/MTP/mtp.html	San Antonio-Bexar County Metropolitan Planning Organization
5	All Resource Categories	Texas Metropolitan Mobility Plan Update: Breaking the Gridlock - a need-based plan that serves as "a conceptual analysis of transportation needs that provides a menu of options" through which to address major transportation issues seen in all eight of Texas' largest metropolitan areas ("Transportation Management Areas"). http://www.dot.state.tx.us/btg/tmmp.pdf	San Antonio-Bexar County Metropolitan Planning Organization

Table 5-21: Resource Conservation/Protection and Mitigation Programs Related to Potential Cumulative Impacts of Proposed US 281 Corridor Project from Loop 1604 to Borgfeld Drive

#	Target Resource	Program/Project Name and Description	Development/ Planning Entity
D. Recent/Current Litigation with Implications for Natural Resources Mitigation Programs			
1	Ecological Resources: Endangered Species	Center for Biological Diversity (Files lawsuits on behalf of sensitive or rare species). Lawsuit maintains critical habitat designations too small (about 30 acres) freshwater invertebrates (Pecos Cave amphipod, Comal Springs dryopid beetle + Comal. Springs Riffle beetle) should be entire aquifer. Notes 90% reduction for 9 Karst invertebrates (draft 9516 ac, final 1663 ac . http://www.biologicaldiversity.org/species/invertebrates/Comal_Springs_dryopid_beetle/index.html	Center for Biological Diversity
2	Ecological Resources: Endangered Species	Whooping Crane Lawsuit Aransas Project has filed suit against TCEQ under ESA for Whooping Crane deaths. Claims agency allowed too many diversions along Guadalupe & San Antonio Rivers, resulting in whooping crane deaths. http://www.prnewswire.com/news-releases/the-aransas-project-files-federal-lawsuit-against-texas-commission-on-environmental-quality-officials-for-illegally-harming-endangered-whooping-cranes-87302352.html	Aransas Project
3	Water Resources: Edwards Aquifer Ecological Resources: Endangered Species	US 281/Loop 1604 Lawsuit - Aquifer Guardians in Urban Areas (AGUA) has filed a federal lawsuit to protect the Edwards Aquifer and endangered species living in the Aquifer's recharge zone, charging that planning for the US 281/Loop 1604 Interchange violates the National Environmental Policy Act and Endangered Species Act. The lawsuit is still pending as of April 2012. http://www.aquiferguardians.org/PDF/News_release_1604_interchange_lawsuit.pdf	AGUA

Source: US 281 EIS Team, 2011

Governmental Mitigation Initiatives for Threatened and Endangered Species

Protection for rare, threatened and endangered species and their habitat in the Vegetation and Wildlife and Threatened and Endangered RSAs is accomplished in a variety of ways. At the regulatory and policy level, recovery plans for endangered species are drafted which enumerate population levels, locations of known populations and habitat areas for subject species and what the degree of threat is to the species. These recovery plans also attempt to quantify population levels which need to be maintained in order to consider the species viable within and throughout its entire range. Similarly, habitat conservation plans (HCPs) are often created by local governments or individuals in coordination with the USFWS in order to simultaneously protect sensitive natural resources and facilitate orderly development through careful predictive incidental impact or "take" of the species covered by the plans. Within the US 281 RSAs, as of fall 2010, there are existing draft HCPs for Hays and Comal Counties as well as two very comprehensive efforts underway for multi-county, multi-species HCPs for the Edwards Aquifer and the southern Edwards Plateau: The Southern Edwards Plateau HCP (SEP-HCP) and the Edwards Aquifer Recovery Implementation Program (EARIP). The SEP-HCP is likely to be the most relevant to terrestrial, non-aquatic endangered species. This HCP covers Bexar, Kendall, Kerr, Comal, Blanco, Bandera, and Medina counties with an emphasis on the needs of the citizens of San Antonio and Bexar County, the areas experiencing the most growth. At present, the SEP-HCP is anticipated to cover the golden-cheeked warbler, the black-capped vireo, the Madla Cave meshweaver), two ground beetles (*Rhadine exilis* and *Rhadine infernalis*), and Tobusch fishhook cactus. The plan will also probably consider addition of non-listed species which would be reasonably likely to become listed in the next 5 to 10 years (Loomis 2010a).

The SEP-HCP sponsors (City of San Antonio and Bexar County) anticipate careful coordination with ongoing HCP efforts in Comal County (in draft stage) and the Edwards Aquifer Recovery Implementation Program (EARIP HCP) to ensure adequate coverage and protection for the full range of affected species and proposed activities. A draft SEP-HCP is not anticipated until late 2010 or early 2011 (Loomis 2010b).

The EARIP HCP is also in a fairly early stage of development and is focused upon aquatic species associated with springs. The proposed incidental take permit will cover seven species listed as endangered or threatened within the permit area. These species include: fountain darter (*Etheostoma fonticola*), San Marcos salamander (*Eurycea nana*), San Marcos gambusia (*Gambusia georgei*), Texas blind salamander (*Eurycea rathbuni*), Peck's cave amphipod (*Stygobromus pecki*), Comal Springs dryopid beetle (Stygoparnus comalensis), and the Comal Springs riffle beetle (*Heterelemis comalensis*). The USFWS will also evaluate possible impacts to species not listed here, such as Texas wild rice and the whooping crane.

Counties that may be included in the proposed permit area are those counties within the EAA jurisdiction to manage the Edwards Aquifer including all or portions of eight counties; Atascosa, Bexar, Caldwell, Comal, Guadalupe, Hays, Medina and Uvalde.

The ensuing section addresses the federally-listed species most likely to potentially create issues for the proposed expansion of US 281. These subsections address current locality information, areas where the species are protected, and conservation programs either underway or in the works that will hopefully assure their survival.

Golden-cheeked Warbler (known localities of protected areas)

The golden-cheeked warbler is the only Texas bird which breeds only within Texas. Within the GWCA RSA, areas of protected habitat include the Department of Defense Camp Bullis, the TPWD Government Canyon State Natural Area, Guadalupe River State Park, and Honey Creek State Natural Area.

Camp Bullis

During a presentation given in 2010 to the SEP-HCP Citizens Advisory Committee, the environmental attorney representing Camp Bullis, stated that approximately 10,000 of the 28,000 acres of Camp Bullis supported potential habitat for the endangered GCWA and that the amount of warbler habitat known to be occupied and the number of birds known to occur on the installation has increased steadily over the past two decades. Biologists suspect that some of the increase is due to habitat loss in the vicinity of Camp Bullis, such as new subdivisions built in dense woodlands. The City of San Antonio has passed a requirement for species surveys that is expected to help stem the loss of GCWA habitat without compensatory mitigation. The attorney described military efforts to acquire conservation credits as mitigation that would enable some habitat on Camp Bullis to be cleared or thinned in order to expand training activities. The USFWS requires such mitigation to be in parcels (or groups of parcels) containing at least 500 acres. The City of San Antonio recently transferred 1,100 GCWA conservation credits to the military that authorized 762 acres of Camp Bullis to be cleared for training purposes. About 604 acres of mostly unoccupied habitat were actually cleared in the past several months and the leftover 158 acres of credits will be used in the next thinning season (Loomis 2010c).

TPWD Government Canyon State Natural Area

The TPWD website describes Government Canyon State Natural Area (SNA) as an approximately 8,624-acre area in Bexar County, just outside San Antonio. The canyon was on the "Joe Johnston" Road from San Antonio to Bandera which was blazed by the military at Ft. Sam Houston in the 1850s. The canyon is a part of the rich ranching history of Texas. The SNA was purchased by TPWD in 1993, in cooperation with EAA, SAWS, the Trust for Public Land and the federal government Land and Water Conservation Fund. The park opened to the public on October 15th, 2005 (TPWD 2010b).

TPWD Guadalupe River State Park

The TPWD website describes the Guadalupe River State Park as a 1,938.7-acre facility located along the boundary of Comal and Kendall Counties; it was acquired by deed from private owners in 1974. The park was opened to the public in 1983. The park is bisected by the clear-flowing waters of the Guadalupe River and noted for its ruggedness and scenic beauty (TPWD 2010c).

Honey Creek State Natural Area

The TPWD website describes Honey Creek SNA as a 2,293.7 acre property located in western Comal County, approximately 30 miles north of downtown San Antonio (see map 3-1). The area, once a ranch, was acquired by deed from the Texas Nature Conservancy in 1985 and from a private individual in 1988; it was opened for limited public access in 1985 (TPWD 2010d). As of 2004, the area supported 22 GCWA territories (USFWS 2004).

Black-capped Vireo

Research is underway to better understand the distribution, life history, habitat requirements, and land management practices affecting the black-capped vireo. Population surveys during the breeding season are being conducted in known and potential habitat areas. Efforts to provide information and educational opportunities to landowners and the public regarding life history and habitat requirements of the vireo are also a vital part of the recovery effort. Research is ongoing regarding the impact of cowbirds on vireo populations in Texas. Research efforts in Mexico are also underway to gather information concerning life history, habitat requirements, and conservation threats on the wintering range. TPWD biologists are monitoring populations on both state and private lands, and voluntary cowbird trapping is being conducted by more than 400 landowners in counties throughout the range of the vireo.

Major research and/or recovery efforts are being conducted on Travis County and the City of Austin's Balcones Canyonlands Preserve, the USFWS Balcones Canyonlands National Wildlife Refuge, and in Mexico. Additionally, active management and research programs are currently underway at the four primary BCVI population centers located on Fort Hood Military Reservation (Texas), Kerr WMA (Texas), Wichita Mountains WR (Oklahoma), and Fort Sill Military Reservation (Oklahoma).

Habitat recovery efforts, including more progressive approaches to brush management, have also been initiated. The NRCS can fund brush management projects that protect and enhance BCVI habitat for up to 50,765 acres of suitable habitat, which comprises 3.5 percent of the estimated suitable habitat in Texas (Wilkins et al. 2006). Environmental Defense recently began a program for establishing Safe Harbor Agreements with private landowners participating in management programs aimed to benefit the BCVI in 37 Texas counties. Other efforts include BCVI habitat restoration by The Nature Conservancy (TNC) at the Barton Creek Habitat Preserve in Travis County, Dolan Falls Preserve in Val Verde County, Love Creek Preserve in Medina County, and Independence Creek Preserve in Terrell County, Travis County, City of Austin, and LCRA initiated land management programs aimed at enhancing and protecting BCVI habitat in Travis County (Wilkins et al. 2006). Also, state and federal agencies along with conservation organizations and university partners monitor and manage endangered species habitat, including BCVI habitat, in the Leon River basin in Hamilton and Coryell counties. This program actively enrolls landowners in management contracts to enhance habitat. Although for many habitat restoration programs it is too early to identify long term effects on BCVIs, efforts to improve BCVI habitat at Cedar Ridge Preserve in Dallas County resulted in the first record of BCVI in that county since 1997 (Wilkins et al. 2006).

Lastly, habitat conservation planning is underway in counties such as Travis and Bexar to allow for urban expansion and development while still conserving endangered species habitat. This planning effort provides information, technical assistance, and incentives for private landowners to incorporate management for black-capped vireos into their livestock and wildlife operations and is considered an essential part of the recovery process (Armstrong et al. 1992; USFWS 1996b).

Karst Species

The USFWS regulates impacts to species that are federally listed as threatened or endangered. The USFWS, under Section 7 of the Endangered Species Act, ensures that federal agencies aid in the conservation of listed species by ensuring that activities carried out by those agencies do not result in negative impacts to designated critical habitats or that the continued existence of the species is not jeopardized by their activities.

A recovery plan for listed Bexar County karst invertebrates has not yet been completed, but is in progress by USFWS (USFWS 2008). Management plans for listed karst species have been implemented at the Camp Bullis Training Site, Government Canyon SNA, and the La Cantera development. Under an agreement with USFWS, the implementation of these management plans exempted those lands from inclusion in critical habitat designations. The voters of San Antonio approved Proposition 3 on 6 May 2000, authorizing the acquisition of open space over the Edwards Aquifer Recharge Zone. Among lands subsequently protected were the Crownridge Canyon and Medallion properties, which contain caves containing *Cicurina madla* and *Rhadine infernalis* infernalis. Much of the Proposition 3 lands remain uninvestigated for caves, so it is possible that unknown listed species sites are now protected by this initiative. The Texas Cave Management Association owns and manages Robber Baron Cave in the Alamo Heights Karst Fauna Region, which contains two federally endangered karst species.

One of these, the Cokendolpher cave harvestman (*Texella cokendolpheri*), is known only from this site.

Table 5-22: Mitigation Measures Affecting Threatened and Endangered Karst Invertebrate Species

Species	Counties	Mitigation Measures
Myotis velifer	Bexar, Comal	Camp Bullis Karst Species Management Plan
Rhadine exilis	Bexar, Comal	Camp Bullis Karst Species Management Plan GCSNA Karst management and Monitoring Plan La Cantera Habitat Conservation Plan
Rhadine infernalis	Bexar	GCSNA Karst Management and Monitoring Plan La Cantera Habitat Conservation Plan Proposition 3 lands
Texella cokendolpheri		TCMA Robber Baron Management Plan
Neoleptoneta microps	Bexar	GCSNA Karst management and Monitoring Plan
Cicurina baronia		TCMA Robber Baron Management Plan
Cicurina madla	Bexar, Comal	Camp Bullis Karst Species Management Plan GCSNA Karst management and Monitoring Plan La Cantera Habitat Conservation Plan Proposition 3 lands
Cicurina vespera	Bexar	GCSNA Karst management and Monitoring Plan

Source: Us 281 EIS Team, 2011

5.8.3 Aquifer Species

A major threat to aquifer species is loss of habitat, whether temporary or permanent, from diminished spring flows and aquifer levels. Most regulatory measures focus on activities in and over the Edwards Aquifer because there are federally-listed threatened and endangered species known from the aquifer and because there are specific regulations in place to address the resource, such as the TCEQ Edwards Aquifer Rules, and the jurisdiction of the EAA. The Authority regulates the use of pumped groundwater by establishing pumping limits for municipal, industrial and irrigation use in an effort to protect water quality, habitat, and water supply.

Some of the species occurring in the Edwards Aquifer also occur in the Trinity Aquifer, and the occurrence of some aquifer species in both the Trinity and the Edwards aquifers demonstrates that at least some aquifer fauna are not bound by aquifers as geologic units. The Trinity Aquifer receives less environmental regulation than the Edwards Aquifer, but should be considered no less biologically important.

Public-Private Mitigation Strategies

Another set of important conservation initiatives are those geared toward providing incentives and assistance to private landowners to undertake voluntary conservation and stewardships efforts aimed at (1) restoring and/or managing habitat for rare, threatened or endangered species known to occur on their properties, (2) implementing watershed management efforts to protect and improve the quality -and quantity of surface and ground waters; and (3) preserve open space and landscape and aesthetic values. One of the more successful of the habitat conservation tools is called a Safe Harbor Agreement. Under a Safe Harbor agreement, a landowner commits to the

USFWS to restoring or enhancing habitats of endangered wildlife, and is thereby protected from future regulations that would normally be imposed if the number of endangered species increases on his land. This simple tool, invented by Environmental Defense in 1994, has resulted in more than three million protected acres across the country that assist in conservation efforts for species ranging from the black-capped vireo to the Houston toad (Environmental Defense Fund 2011).

Another program which is used both for rare species and their habitat as well as for wetlands protection and restoration is the USFWS Partners for Fish and Wildlife initiative (PFW). This program was initiated in Texas in 1990 to restore and enhance fish and wildlife habitat on private lands. The PFW program initially targeted wetland habitat for restoration and enhancement work; however, its early success encouraged the USFWS to expand it to benefit habitats for all federal trust resources, including waterfowl, other migratory birds, and candidate, threatened, and endangered species. Projects typically involve wetland, native prairie, and/or riparian restoration activities. The PFW program provides cost-sharing and technical assistance to non-federal landowners, including private landowners, local governments, Native American tribes, educational institutions, and other entities.

Nationwide restoration accomplishments from 1987 to 2002 include 639,560 acres of wetlands, 1,069,660 acres of prairie and other uplands, 4,740 miles of streamside and in-stream habitat, and 28,725 landowner agreements. The PFW program is very well received by participating private landowners, known as Cooperators. Several Cooperators have been honored as recipients of National and Regional wetland stewardship awards and also with local "Wildlife Conservationists" awards. Close working relationships exist with personnel from the Natural Resource Conservation Service (NRCS), local Soil and Water Conservation Districts, TPWD, Texas Forest Service, other government agencies, and private organizations such as Ducks Unlimited (USFWS 2010b). Central Texas projects in the US 281 ecological RSAs data collection area include black-capped vireo habitat restoration in Blanco and Kendall counties and assistance with cave gating in Bexar County (USFWS 2010b). Other somewhat successful federal incentive assistance programs aimed at landowners are the Environmental Quality Incentives Program (EQUIP), under which NRCS provides assistance to landowners to improve water supplies by clearing cedar, planting native grasses and restoring open space. The US Department of Interior also promotes strategic conservation efforts through its innovative Landscape Conservation Cooperatives (see **Table 5-22**).

These voluntary conservation measures provide economic and other benefits to landowners and also benefit neighbors and members of rural communities through the ecological, psychological, and recreational benefits of preserving wild lands and open space (Ikard 2009). Under state law, these measures are of two types: the first is conservation easements, which allow a landowner in essence to extinguish the developmental rights associated with the property by transferring them, usually in perpetuity, to a willing grantee, such as the Nature Conservancy. If the grantee is a 501(c)(3) non-profit, significant federal tax deductions are available for such donations. A second approach is to obtain a local property tax valuation based upon restricted use, as authorized by state law and the Texas Constitution, Article VIII Section 1-d-1. Like agricultural valuation, these so-called “1-d-1” valuations are based on the productivity of the land rather than its market value, which in rapidly urbanizing areas can be the difference between holding on to a family farm or ranch or selling to developers. The uses allowed for this type of exemption are management for wildlife propagation and use for research as an ecological laboratory. Since the productivity value of such activities is very low, these uses can in some cases reduce local property taxes to near zero.

To qualify for a wildlife management exemption, the property owner must engage in at least three out of the following seven propagation methods: (1) habitat control; (2) erosion control; (3) predator control; (4) providing supplemental supplies of water; (5) providing supplemental supplies of food; (6) providing shelters; and (7) making of census counts to determine population. The law also requires a minimum amount of land but allows a group of neighboring landowners to form a wildlife management property association and all receive 1-d-1 classification. Subdivision developers have found this provision useful in some areas where a development area can be clustered and still leave sufficient space to preserve viable habitat. To qualify as a wildlife management property association, each state level conservation programs have proven particularly effective in many areas because they are linked to state and local property tax incentives authorized by state law (Ikard 2009).

5.8.4 Anticipated Effects of Mitigation Measures and Resource Protection Priorities

Table 5-21 summarizes specific, on-going resource conservation and preservation programs and projects by governmental agencies and private conservation interests that will individually and collectively minimize direct, indirect, and cumulative effects to environmental resources.

Direct and indirect effects to wildlife habitat and water quality within the construction corridor will be monitored and controlled in accordance with federal, state, and local regulatory provisions discussed in **Section 5.8.1** above, and enforced through the environmental provisions of the Comprehensive Development Agreement (CDA) between the Alamo RMA and the US 281 Corridor Project developer. These construction requirements, both regulatory and contractual, include the use of BMPs, vegetation clearing techniques (such as conducting clearing outside bird nesting periods or avoiding disturbance to active nests during the nesting season), and re-vegetation of disturbed construction areas with native plants indigenous to the area. Adjacent vegetated areas would be protected from storm water runoff by implementing BMPs designed to control erosion, post-construction total suspended solids, and sedimentation control. Clearing of vegetation would be limited and/or phased to maintain a vegetated water quality buffer and minimize the amount of erodible earth exposed at any one time. Upon completion of earthwork operations, disturbed areas would be restored and seeded according to TxDOT's Vegetation Management Guidelines and in compliance with the intent of the FHWA Executive Memorandum on Economically and Environmentally Beneficial Landscape Practices and the Executive Order on Invasive Species.

Through the implementation of the conservation plans, policies, and regulations identified in **Section 5.8.1** that are intended to protect environmental resources and the human quality of life, cumulative impacts associated with past, present, and future development within the area can be reduced. Through actions brought by the COSA endangered species ordinance and conservation efforts by the Bexar County Karst Recovery Plan, Southern Edwards Plateau Regional Habitat Conservation Plan, Comal

County Regional Habitat Conservation Plan and Edwards Aquifer Recovery Implementation Program, cumulative effects to land, ecological, water, historic, and archeological resource categories can be reduced. Cumulative effects to the land and community resource categories will be reduced through implementation of and adherence to comprehensive community development plans such as those listed in **Section 5.8.1** .

From the longer term perspective, the cumulative effects of land development within the US 281 AOI must be evaluated as irreversible and irretrievable effects on human and natural resources. With future development activities projected to result in substantial land use changes for over roughly a quarter of the AOI, these effects cannot be viewed as other than substantial, with the US 281 project-induced component making a minor but not inconsequential contribution.

Section 5.8.1 described the network of statutory and regulatory controls available at federal, state and local levels. These tools make an important contribution to area resource protection goals. Nonetheless, due to inherent limitations of authority, jurisdictional boundaries, and enforcement issues, these laws, regulations, and ordinances have not prevented the rapid growth in San Antonio and surrounding areas from contributing to a continuing, and in some areas substantial decline in natural resource viability.

The capabilities of governmental mechanisms to exert effective land use and resource protection controls in unincorporated areas – like the US 281 AOI, for the most part – has been and will probably continue to be limited. The advent of more effective land development controls in areas outside incorporated cities is not likely to occur in the near or even middle term of the planning horizon of this study. It is axiomatic in most parts of Texas that the political culture is staunchly protective of individual property rights, and resists increases in government spending for conservation purposes. (In Texas, only two percent of the land area is protected as state or federal land, and Texas ranks 49th among all states in per capita spending on parkland [Ikard 2010]). A few counties on the South Texas border have County land use controls, but those cases are the product of developmental concerns other than environmental protection or conservation (NuStats 2008).

The implications of these observations seem evident: voluntary, cooperative actions by private landowners and developers – in partnership with local governmental and non-governmental organizations – must play an expanding role if trends in declining resource viability are to be reversed and long term sustainability achieved. Trends toward responsible cooperative land stewardship have been evident in the Texas Hill Country, from organizations like the Chalk Mountain Wildlife Management Property Association in Somervell County and others in the southern Hill Country closer to the project AOI, with assistance from organizations like Environmental Defense (ED) and Texas A&M's Institute for Renewable Natural Resources (IRNR) that facilitate the use of public-private assistance programs like NRCS' EQUIP, financial assistance (direct and in-kind), federal and state tax deductions and valuation policies, and others cited in **Table 5-21**.

However, in rapid growth areas like the US 281 AOI, well-intentioned conservation and stewardship initiatives meet the strong headwinds of the real estate market. Effective strategies to accommodate growth demands and preserve property rights, while building on inherent conservation and stewardship inclinations of the landowner and developer communities, will require better understanding and awareness of existing programs and institutional opportunities and even, in some cases, advocacy for modifications of existing laws and ordinances to further facilitate public-private cooperative arrangements. All these efforts require public support, which in turn requires broadening the base of awareness of these issues and opportunities.

Many landowners and real estate and development professionals are very cognizant of the economic, as well as environmental, importance of such strategies. The Texas Hill Country "brand" – a nationally recognized image of scenic beauty and environmental quality – is at the heart of the region's economic vitality and the stability of its land prices. In this sense, the US 281 AOI represents a potential laboratory for furthering strategies of low-impact development, cooperative land stewardship associations, creative development design, and other public-private arrangements aimed at

- Limiting impervious cover while enhancing the water quality function of watersheds
- Minimizing, avoiding, or reversing fragmentation of habitat in high value areas
- Preserving rural landscapes and views
- Voluntary conservation of historic and prehistoric cultural resources
- Integrating information about potential decline of environmental quality as well as opportunities for resource conservation and enhancement into existing and new venues of public education and community awareness.

There are a number of available mitigation measures that are applicable to achieving the goal of minimizing probable effects associated with future land development activities in the US 281 project corridor, cumulative development and other development area. For example, within the universe of land development planning and design practices, an emerging practice known as Low Impact Development (LID) has been shown to have high potential for reducing levels of water quality impacts compared with traditional development designs. In addition, development designs that integrate important environmental resource conservation elements through establishment of strategically located greenbelt areas and corridors and clustering of buildings and transportation systems may facilitate conservation of critical habitat elements.

The potential applicability and more site-specific definition of these types of mitigation measures to future land development within the AOI should be evaluated and determined through cooperative work among the primary interested parties and other stakeholders in the projected future development areas identified in the AOI. The parties to such a discussion would include: land owners; land development professionals; builders and construction industry representatives; chambers of commerce; local government planning and regulatory officials; regional water authorities, including the EAA, Guadalupe Blanco River Authority, and the Upper Guadalupe River Authority; state resource agencies such as the TPWD, TCEQ, and the Texas State Soil and Water Conservation Board; universities and research institutions; transportation planning entities, including the FHWA, TxDOT, the Alamo RMA and transit authorities; school districts; water and wastewater service providers; non-governmental environmental organizations; and other interested members of the citizenry.

As an important step aimed at mitigating the identified environmental impacts associated with both induced development and cumulative land development effects in the US 281 Area of Influence, a working committee of interested parties could be established. One or more working sessions could be held, to include face-to-face meetings as well as follow-up work in subcommittees as appropriate, in order to refine proposals and implementation plans, and ideas for specific mitigation measures, aimed at achieving impact minimization as future land development proceeds throughout the area. Any such work should be linked to existing cooperative efforts for conservation planning and public education.

5.8.5 Integrating Climate Change Considerations into Transportation Planning

In the United States, transportation is the largest source of greenhouse gases (GHG) after electrical generation, and within the transportation sector, cars and trucks account for the majority of emissions. To date, the US government has not adopted a specific GHG reduction goal. However, in 2008, representatives from several federal agencies met to discuss overall opportunities to reduce GHG emissions from transportation sources, through the coordination of federal programs that influence land-use decisions to decrease the growth in vehicle miles of travel. The agencies formed an interagency working group that continues to meet monthly to identify interagency activities that ultimately result in reduced growth in vehicle miles of travel of cars and trucks. FHWA is focusing new attention on coordinating its policies, programs, and funding related to transportation, land use, and climate change to meet the agency's goal of reducing GHG and growth in miles of travel (FHWA 2010).

With regard to the SA-BC MPO's long range transportation plan, the FHWA has stated that climate change should be addressed in the planning process from both mitigation and adaptation perspectives. The FHWA states that the "broad geographic scope and time scale of the planning process makes it an appropriate place to consider GHG emissions and the effects of climate change" (SA-BC MPO 2009a).

Climate change and related effects are complex and there is not yet a single approach to addressing these issues. FHWA has recently focused its resources on supporting transportation and climate change research and disseminating the results to MPOs, providing technical assistance to stakeholders, and coordinating its activities with other federal agencies. Climate change considerations can be integrated into many planning factors, such as supporting economic vitality, increasing safety and mobility, enhancing the environment, promoting energy conservation, and improving the quality of life.

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